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THE Association was organized in Boston, Mass., on June 21, 1882, with the object of providing its members with means of social intercourse and for the exchange of knowledge pertaining to the construction and management of water works. From an original membership of only TWENTY-SEVEN, its growth has prospered until now it includes the names of 900 men. Its membership is divided into six classes, viz.:

A Member shall be an officer or employee of a public or private water works, an engineer, chemist or other person qualified to aid or interested in the advancement of knowledge relative to water works.

An Honorary Member shall be a person of acknowledged eminence in some branch of water supply or of engineering.

A Junior shall be not less than eighteen years nor more than twenty-five years of age, a student or connected with water supply work.

An Associate shall be either a person, firm or corporation engaged in manufacturing or furnishing materials or supplies for the construction or maintenance of water works.

A Corporate Member shall be either a Water Board, Commission, Company or Municipal Corporation.

The initiation fees and annual dues are as follows:

	Initiation Fees	*Annual Dues*
Members	$ 3.00	$ 6.00
Juniors	1.00	3.00
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This Association has at least eight regular meetings each year, of which five are held in Boston, one in northern New England, one in southern New England, and one, the annual convention, held in September on such date as the Executive Committee may designate.

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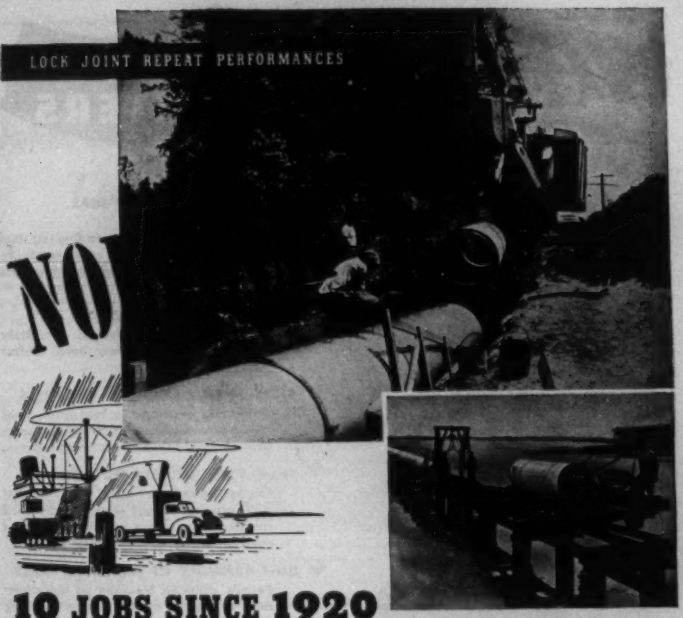

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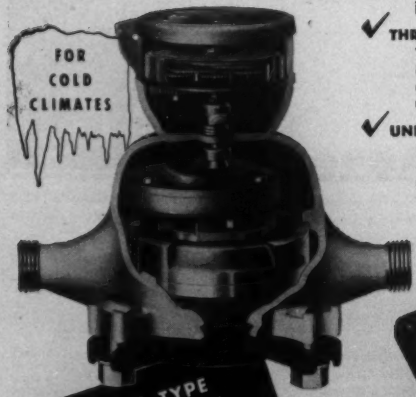

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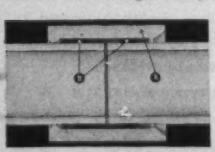

This cutaway sketch shows construction of the Simplex Coupling used with Transite Pressure Pipe. It consists of a Transite Sleeve "A" and two rubber rings "B" which are tightly compressed between sleeve and pipe when the coupling is assembled.

This aerial view shows a portion of the Naval Ordnance Test Station at Inyokern, California.

The reason this Transite installation was able to withstand this severe test is found in the inherent strength of the pipe and in the design of its Simplex Coupling, the standard coupling for Transite Pressure Pipe. Each of these couplings is a tight yet flexible link connecting one section of pipe to another and imparting to the line as a whole a degree of flexibility which enables it to "roll with the punch." Thus, shocks and vibrations are absorbed, stresses minimized to an unusual degree.

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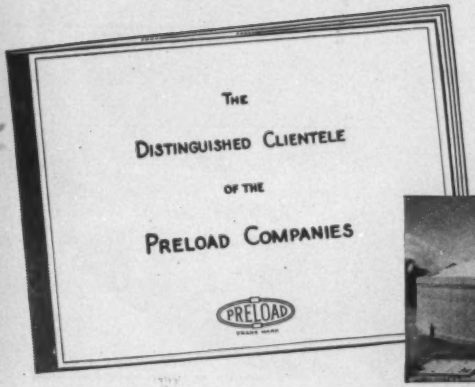

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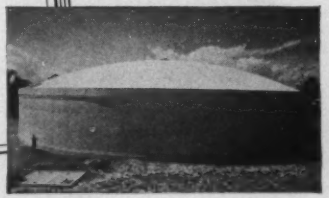

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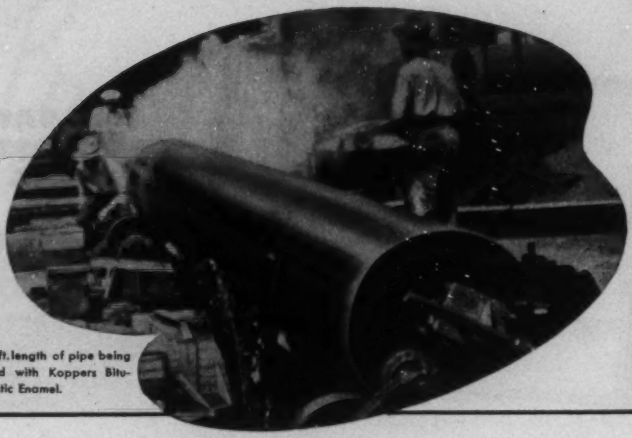

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VARIES MORTAR-THICKNESS ACCORDING TO NEED

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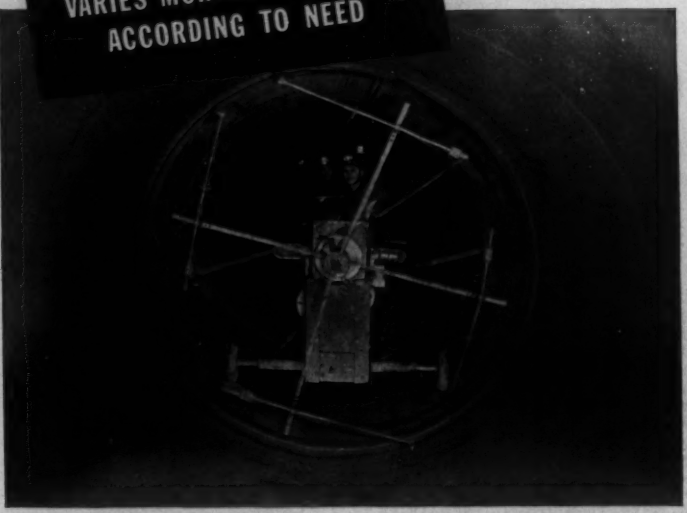

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Milwaukee has many thousands of Badger Meters in use, ranging from 5/8" to 12" sizes, in Disc, Compound, and Turbine types. In more than 5,000 communities, waterworks men know "It pays to *buy* BADGER."

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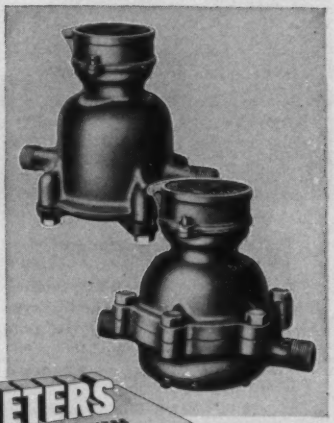

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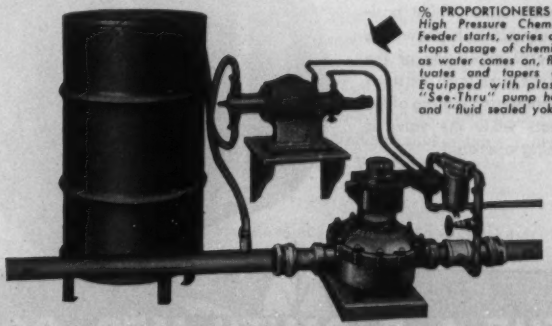

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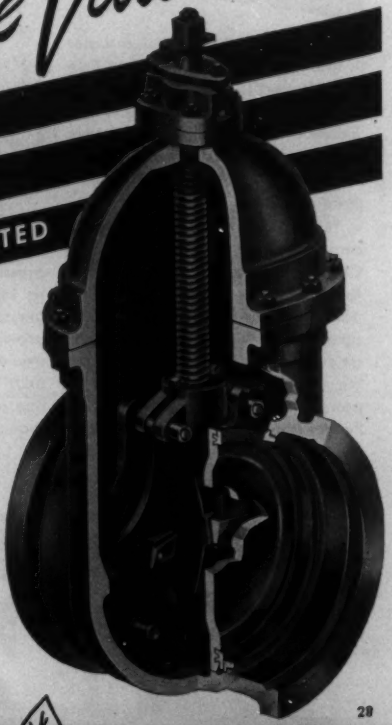

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New England Water Works Association
ORGANIZED 1882

VOL. LXII DECEMBER, 1948 NO. 4

This Association, as a body, is not responsible for the statements or opinions of any of its members

A STUDY OF SLUDGE DISPOSAL AT WATER PURIFICATION PLANTS IN NEW ENGLAND

BY FRED E. SMITH*

[*Read May 20, 1948.*]

THIS paper consists of extracts from a thesis submitted at the Harvard Graduate School of Engineering. The thesis was entitled "Disposal of Sludge Produced in Water Purification" and was a requirement of the course in Industrial Wastes and Municipal Refuse. The scope of the study was restricted to sludge production and disposal from iron and aluminum coagulation of water at New England plants. Experience elsewhere was briefly mentioned, but only minor consideration was accorded primary sedimentation and water softening.

Classification of sludge as an industrial waste required considerable discussion of sedimentation-basin construction and operation. This procedure was adopted because every water supply requires individual study of all aspects of purification, with special emphasis on filter-plant design and operational procedures selected for treatment of the supply. This individuality of water supplies also renders of little value the comparison of operating and production data of filter plants, in contrast with readily comparable studies of processes involved in the manufacture of similar industrial products.

An extensive search of water and sewage literature yielded very little material dealing with filter-plant sludge disposal. If available, professional journals of the period 1927-1947 were examined. It was found that in both design and operation papers little, if any, mention was made concerning sludge disposal, except to state "sludge is pumped to the drain."

*Chemist, Water Department, Cambridge, Mass.

Water Purification Data

Based on a national survey by the United States Public Health Service in 1943 (1), there are 1,535 mechanical or rapid-sand filter plants in this country. These plants are utilized for purification only, none providing softening as a part of the water treatment. Rapid-sand plants serve 22.9 million population and produce 2,600 mgd.

These statistics establish the fact that water purification, although classified usually as a public or private utility, can be considered an important industry in this country. As all water-supply systems and most of the purification plants are in continuous operation throughout the year, production of wastes, which are sedimentation-basin sludge and used wash water, is also uninterrupted by lengthy shutdowns. Hence, waste-disposal procedures must be based on these conditions with reference to storage, treatment and disposal details.

Sludge Production

Material removed in water purification by primary sedimentation consists of silt, mud and coarse suspended matter that will settle readily without a coagulant. If coagulation is used, the impurities adsorbed or enmeshed by the coagulant are settled to the bottom of the basin. The volume of silt, dirt, color, bacteria and microscopic organisms accumulated in both types of basins is a sludge, the disposal of which frequently creates a problem in filter-plant operation.

In an industrial-waste study, the volume of waste produced can usually be predicted on the basis of experience at similar plants. For instance, the volume of waste per pound of scoured wool, or per ton of paper pulp, will be reasonably comparable at several plants. In filter-plant operation, however, even the number of basin cleanings per year varies so markedly at different plants, that comparisons of sludge production per million gallons of water treated become impossible.

Three general conditions which influence the production and accumulation of sludge in sedimentation basins are:

1. Character of water being treated;
2. Efficiency of coagulation;
3. Basin performance.

If the water is highly colored or contains considerable amounts of turbidity, possibly in addition to large growths of microscopic organisms, the volume of sludge produced will obviously be large. Temperature of the water also affects sedimentation, because with cold water and increased viscosity, the rate of particle settlement per unit of time is decreased. Efficiency of coagulation depends upon the applicability of the coagulant to the water, the rate of coagulant dosage, and effect of temperature and pH on the reaction of coagulant and water. Some factors in reference to basin performance are construction details, effect of baffles, absence of short-circuiting, and the interval between cleanings. Little mention is found in water-works literature concerning the volume of sludge produced in filter-plant operation. The basins at the Cambridge plant are 16 ft deep and are cleaned when the sludge depth is 6 ft. Sludge volume is approximately 590,000 gal, about a third of the total basin capacity of 1.5 mil gal.

Sludge Characteristics

Sludge produced in the coagulation of New England water supplies generally has a high moisture content, which renders the sludge free-flowing and enables pumping to be accomplished without difficulty. Color is brown or black, and odor is always present in sedimentation-basin sludge. The intensity of the odor is stronger when the water temperature is high. This effect is noticeable in warm weather at the Cambridge plant during basin cleaning, when the supernatant has been removed and heavy sludge is being pumped. Almquist (2) determined the average B.O.D. of sludge from 13 Connecticut filter plants to be 337 ppm. A few simple experiments on settlability of sludge were done at the Cambridge plant. The samples were collected at mid-depth of accumulated sludge, 4 ft deep, and were thoroughly stirred to simulate the effect of pumping. A liter volume of sludge settled and compacted to a volume of 600 ml in two hours.

Basin-Cleaning Procedures

With covered concrete basins, the general procedure of cleaning consists of unwatering the unit and pumping the sludge to the drain. The upper layers of water, or supernatant, may be pumped or drained

to the sewer or reservoir, or in some instances are mixed with incoming raw water. Fire hoses are used to remove any sludge remaining on walls or bottom. After cleaning, the basin is refilled with coagulated water and is placed in service again.

Frequency of cleaning of basins depends upon several conditions. Cleaning should be done at suitable intervals to prevent shortening of the detention period by sludge accumulation. Sludge decomposition, with production of odor or taste in the water, may require more frequent cleaning of basins in summer months. Other factors which have influence in this matter are flexibility of plant operation, to permit cleaning during periods of peak consumption loads, and any possible seasonal restriction on the procedure of sludge disposal. At the Cambridge plant the basins are cleaned at three-week intervals in summer and six- to eight-week intervals in winter. Other New England plants clean their basins only semi-annually or at irregular intervals during the calendar year.

Mechanical Cleaning Procedures

In the past 20 years mechanical cleaning of sedimentation basins has been installed by many filter plants. Most installations have been made at plants treating turbid waters which produce large volumes of sludge. Softening plants also use this equipment. Advantages claimed for mechanical removal of sludge are (3):

1. Freedom from manual cleaning;
2. Continuous operation;
3. Elimination of duplicate units;
4. Low operating cost;
5. Maintained efficiency of the unit as regards detention period;
6. Possibility of increased pollution of water by decomposing sludge is minimized;
7. Disposition of sludge in unit quantities.

It is apparent that in the above list there are factors which would increase the efficiency of a filter plant burdened with a highly turbid water or with inadequate settling capacity. An unusual procedure for sludge removal was adopted in Philadelphia to clean an open

coagulation basin, loaded with a heavy accumulation of sludge (4). A dredge was floated in the basin and the sludge was pumped to a disposal basin, in which the supernatant depth was controlled. This water was released to the Schuylkill river at 50-ppm turbidity. Plant operation was not interrupted and it was planned to use the sludge for fill.

Daily Sludge Removal

A suggested procedure (5) for basin cleaning utilizes perforated tile laterals in the bottom of the basin as underdrains. Sludge is drawn by quick-opening gate valves. If the valves are opened and sludge is withdrawn daily, the following advantages are claimed:

1. Increased basin efficiency;
2. Reduction in number and size of required basins;
3. Reduction in operating and maintenance costs;
4. Low initial cost;
5. Adaptability to modification in the individual treatment;
6. Reduction of stream pollution;
7. Prevention of sludge decomposition;
8. Flexibility in design and operation;
9. Negligible cost of operation.

A difficulty with this suggested procedure is the formation of a cone in the sludge layer when the drain valve is opened. The supernatant flows through the cone before much of the sludge can be withdrawn. The writer has observed this condition when attempt was made to pump sludge from a basin in operation. Baylis has stated (6), "The writer is not aware of any basins with underdrains being constructed within the past few years, and it is not likely that basins of this type will come into general use."

Disposal of Sludge

Filter plants using preliminary sedimentation invariably are supplied with water from highly turbid streams or rivers. The sludge is principally inorganic suspended matter of gross particle size and settlement is accomplished without a coagulant. Disposal is commonly done by discharging the sludge into the river below the filter plant, frequently by means of a separate sewer.

Disposal of sludge from coagulation basins may be done by one of the following procedures, which are discussed in detail.

Disposal of Sludge with Domestic Sewage

As most sedimentation basins are cleaned by completely unwatering, the volume of sludge pumped to the sewer will be received as a slug. Within a period of a few hours, several hundred thousand gallons of sludge will be discharged, the amount depending on the size of the basin and the interval between cleanings. If no sewage treatment is provided, the following conditions should be considered:

1. Possible silting of the sewer;
2. Availability of adequate dilution in the receiving stream for the increased load.

New England water supplies contain few suspended solids and the sludge produced by these supplies is usually free-flowing. If the size of the sewer is adequate, with correct engineering grades, the possibility of silting is negligible. One difficulty that is sometimes experienced is inadequate size of the sewer connecting the filter plant with the trunk sewer. This condition developed when the Cambridge plant was first placed in operation. Until the sewer was enlarged, sludge pumping was restricted to intervals of 30 minutes during basin cleaning.

If the receiving stream or body of water is being used for disposal of domestic sewage without creating a stream-pollution problem, it is probable that disposal of sludge with the sewage can be satisfactorily done. The B.O.D. of the sludge will not greatly exceed that of the sewage and the volume of the sludge will be a relatively small fraction of the total sewage flow, even for a single day.

Sedimentation-basin sludge being classified as a trade waste, the following points should be considered (7) prior to adding sludge to domestic sewage, treated at a disposal plant:

1. Will the waste damage the sewer system?
2. Is the waste amenable to existing processes of treatment?
3. Can the sewage-treatment plant handlle the additional volume of industrial waste?

4. Is the strength of the waste sufficient to interfere with the treatment process?
5. What will be the effect on the final plant effluent?

Sludge will not damage the sewer system and the composition of the waste does not present a serious problem to typical sewage-disposal plants. The volume of sludge normally received as a slug at a disposal plant may cause an overload, if its arrival coincides with peak sewage flows. This condition can be remedied by the cleaning of basins during hours of minimum sewage flow. The volume of sludge discharged to the sewer can be materially reduced by settling in a separate tank, thereby lessening the load of a heavily burdened sewage-disposal plant.

The sewage-plant operator will be concerned with the suspended solids and mineral content of the sludge. Little deposition of suspended solids will occur in the grit chamber and disposal of grit-chamber material as fill will not be affected. The bulk of the suspended solids will settle in primary sedimentation tanks, thereby increasing pumpage to the digesters. If Imhoff tanks are used, the suspended material will settle in these units. When the relatively small volume of sludge is considered with total sewage flow, it is apparent that the suspended material and mineral content of sludge will not seriously affect sewage-plant operation, provided that the plant is not already overloaded. No account of interference with sewage treatment by filter-plant sludge, except by that of softening plants, was found in water or sewage literature. Wisely (8) has stated that apparently there have been few, if any, problems of this kind that have merited mention in the literature.

Disposal of Sludge in River or Stream below Filter Plant

Satisfactory disposal of sludge in streams or rivers is dependent on stream flow for adequate dilution. The flow of water should be sufficient to remove the sludge without creating sludge banks or deposits near the filter plant. The possibility of rendering the stream unfit for use below the filter plant must be considered. Release of sludge during peak or flood flows is practiced. Also, if plant operation permits, minimum sludge discharge could be done in summer

months, when low stream flow usually prevails and nuisance conditions could more readily occur.

Filter plants at Bangor and Biddeford, Me., and Lawrence, Mass., pump raw water from large rivers. Disposal of sludge and used wash water in these streams with ample dilution is a practical and economical method.

Disposal of Sludge in Reservoirs, Lakes or Ponds

Factors to be considered with this method of sludge disposal are availability of adequate dilution, possibility of sludge banks, and the use of the body of water as water supply by other filter plants.

At the Cambridge plant, sludge in indeterminate volume is released to Fresh Pond by gravity during basin cleaning, the greater portion being pumped to the sewer. The outfall is near the pump intake and ample dilution is available. All used wash water at this plant has been pumped into Fresh Pond for the past 17 years. This outfall is at least 1,500 ft from the pump intake. No deleterious effects on the quality of Fresh Pond water have been noted.

It is inescapable that a sludge layer or deposit will accumulate on the bottom of a reservoir used for sludge disposal. However, in most reservoirs the silting effect of sludge will be manifest at a time so distant that a yet-to-be-born generation must cope with the problem.

At Braintree, Mass., Great Pond is used by other filter plants. The Braintree plant (9) is provided with an earthen disposal basin for sludge and used wash water. In this basin the sludge is settled, and the overflow and drain release the water to Great Pond. The bottom of the disposal basin was filled with sand 12 in. deep to facilitate leaching.

Disposal of Sludge in Lagoons

The Salem, Mass., plant was provided with three lagoons for disposal of sludge and used wash water. The lagoons are operated in series (10), the last in the series emptying into Wenham Lake. No problems have occurred and no complaints of odor have been reported. In past years basins at this plant have been cleaned at intervals of four months, so the volume of sludge has not been comparatively large.

At Rockport, Mass., sludge and used wash water from a small filter plant were discharged into a swampy area near the north end of Cape Pond (11). Sludge volume was small because, during the summer months, the plant was operated as a supplementary supply only.

Use of lagoons for sludge disposal appears to be a satisfactory method. In the event of increased sludge production by the filter plant, disturbance of old deposits and decrease of the settling period might occur. Under these conditions some sludge probably would be discharged into the reservoir, if the lagoons were overloaded.

Disposal of Sludge by Commercial Use

Two references were found in water-works literature concerning possible commercial use of filter-plant sludge. Rockwell (12) suggests recovery of humic acid and humates, stressing the importance of Canadian waters, polluted by runoff from woods rather than by municipal wastes. The other reference (13) discusses possible use of sludge commercially, but concludes that the only possible use would be as fill. Attempts to recover aluminum have not been encouraging.

Summary

The influence of two conditions is probably responsible for the inattention of plant operators and absence of written material with reference to disposal of filter-plant sludge and wash water. First, the economics of basin cleaning discourage studies to improve current disposal methods. At the Cambridge plant complete unwatering of the basins would represent a loss of 1.5 mil gal at approximately twelve cleanings yearly. With plant production of 17 mgd, the water lost by basin cleaning is of negligible volume. Many plants clean basins only two or three times yearly with even less loss of water. Labor cost is very small.

Secondly, present methods of sludge and wash-water disposal apparently create only nuisance problems. Almquist (2) studied Connecticut disposal methods on this basis. No record has been found dealing with health hazards or even serious stream-pollution effects due to sludge disposal. Suggested corrective procedures for the nuisance problems have been limited to utilization of lagoons, or discharge of sludge during periods of peak stream flow.

The writer concurs with the statement of Almquist (2) that the best procedure for sludge disposal is with domestic sewage, even to the extent of constructing a sewer, if necessary, to obtain access to the trunk sewer. In the case of isolated plants, disposal in a stream, lake or reservoir will serve, under controlled conditions as to available dilution. Possibility of future silting of lakes or reservoirs should be considered. All current disposal procedures can be improved by settling the sludge in a separate tank after removal from the sedimentation basins.

In conclusion, new or modernized filter plants will produce increased volumes of sludge, in order to accomplish more purification ahead of the filters, thereby placing on these units a lesser part of the purification load. It is probable that careful study of sludge disposal will be an important factor in the future design of many filter plants.

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PROCEEDINGS

Sixty-seventh Annual Meeting

New York, N. Y.

September 14 to 17, 1948

The Sixty-seventh Annual Meeting of the New England Water Works Association was held at the Hotel Pennsylvania, New York, N. Y., on September 14 to 17, 1948.

Tuesday, September 14

Morning Session

President Donald C. Calderwood presiding.

The Annual Reports of the Secretary, Treasurer, Editor, Finance Committee, Committee on Legislation, Committee on Committees, Committee on Technical Program, Committee on Membership and Committee on Library were presented and accepted.

The following progress reports of technical committees were presented and accepted: Committee on Rainfall and Yield of Watersheds in New England, Committee on Water Distribution Safety, Committee on Specifications for Cast-Iron Pipe and Fittings, Committee on Reinforced Concrete Pressure Pipe, Hydrant Specification Committee, Committee on Gate Valve Specifications, Committee on Laying Cast-Iron Pipe, Committee on Specifications for Steel Pipe and Committee on Threads for Underground Service Lines.

An informal report was presented by the Committee on Meter Specifications. All formal reports are printed in this issue of the Journal.

The President declared the polls closed and appointed as tellers Sydney C. Beane, Walter C. Conroy and Thomas S. Lawrence.

After a brief discussion of the report of the Committee on Threads for Underground Service Lines, upon motion of Arthur L. Shaw, duly seconded, it was Voted that the Association adopt the specifications for threads for underground service lines as standard.

Afternoon Session

A paper on "Recent Labor Legislation and Its Effects on Public Utility Operation" was read by John H. Murdoch, Jr., Vice-President and Counsel, Water Works Service Co., Inc., New York, N. Y.

A paper on "Production of 84-Inch Prestressed Concrete Pressure Pipe for City of Montreal" was read by R. M. Doull, Manager, The Preload Co. of Canada, Ltd., Montreal, Canada.

Evening

A President's Reception was held in the Salle Moderne, through the courtesy of the Water and Sewage Works Manufacturers Association, Inc.

Wednesday, September 15

Morning Session

A paper on "Insurance Problems of Water Works Companies" was read by Charles C. Goodrich, Insurance Adviser, Hartford, Conn.

A paper on "Watershed Inspections in Connecticut, Including Problems of Housing Developments," was read by Frederick O. A. Almquist, Principal Sanitary Engineer, State Department of Health, Hartford, Conn.

A paper on "Modern Diesel Practice for Water Works Plants" was read by David Gallagher, Public Works Division of Worthington Pump and Machinery Corp., Newark, N. J.

Afternoon

Through the courtesy of the Water and Sewage Works Manufacturers Association, Inc., there was a three-hour boat trip around Manhattan Island.

Thursday, September 16

Morning Session

A paper on "An Inverted Siphon for the Assabet River Crossing of the Wachusett Aqueduct" was read by Stanley M. Dore, Deputy Chief Engineer, Construction Division, Metropolitan District Commission, Boston, Mass.

A paper on "Geological Aspects of the Municipal Ground-Water

Supplies of Cape Cod" was read by Paul F. Howard, of Whitman and Howard, Consulting Engineers, Boston, Mass.

Afternoon Session

A paper on "Seismic Reconnaissance for Ground-Water Development" was presented by Scott Keith, Project Engineer, Metcalf & Eddy, Consulting Engineers, Boston, Mass., and Rev. Daniel J. Linehan, S.J., Seismological Observatory, Weston College, Weston, Mass.

A paper on "Introduction of Pre-chlorination of Slow Sand Filters," prepared by Samuel Jacobson, Chemist and Bacteriologist, and Marshall S. Wellington, Sanitary Engineer, both of the New Haven Water Co., New Haven, Conn., was read by Dr. Jacobson.

A sound moving picture in color, "Water, Water Everywhere," was presented by Ion-Exchange Products Department of the American Cyanamid Co., New York, N. Y.

Evening

A reception was held in the Club Room, Grand Ballroom Foyer, followed by a dinner and entertainment, through the courtesy of Water and Sewage Works Manufacturers Association, Inc.

AWARD OF THE DEXTER BRACKETT MEMORIAL MEDAL

PRESIDENT CALDERWOOD. The next part of our program is one of the most outstanding things that is going to take place here tonight. It is the award of the Dexter Brackett Memorial Medal. I shall call on Charles B. Hardy, who is chairman of the committee on the award of the medal, to make the presentation.

CHARLES B. HARDY. Mr. President, members and guests:

As most of you know, the Dexter Brackett Memorial Medal was instituted in 1916, to perpetuate the memory of Dexter Brackett, who for many years was chief engineer of the Metropolitan water supply in Boston. Mr. Brackett was editor of the JOURNAL for several years, and he was president of our association in 1889 and 1890.

Since then twenty-seven members of this association have been honored by receiving this award. Two of them received it twice and one member received it three times.

This year your committee, having in mind the rules governing the award, were unanimously of the opinion that the most meritorious paper published in the JOURNAL in 1947 was that entitled "Toronto Water Works Extensions—A General Description of the System with Details of Some Outstanding Features." The author, Mr. William Storrie, is one of Canada's leading consulting engineers. He is the twenty-eighth member of this association to receive the award and, I believe, the first from our good neighbor, Canada.

Mr. Storrie has recently served with Mr. Samuel Greeley and Mr. Malcolm Pirnie in making a report on the "Detroit Water Supply and Related Problems." In 1944 he received the George W. Fuller Award from the American Water Works Association and in 1946 the Kenneth Allen Award from the Federation of Sewage Works Associations. That gives him a clean sweep. He is the first man, as far as I know, who has had that distinction.

Mr. Storrie, it is a privilege and a great pleasure for me, on behalf of the New England Water Works Association, to present to you the Dexter Brackett Memorial Medal for 1947.

WILLIAM STORRIE. Mr. President, Mr. Hardy, ladies and gentlemen:

I asked one of your executives if I was expected to speak, after I was presented with this medal, and he said, "Oh, yes, you are expected to say something. You can either talk on nothing at all, on your knowledge of the Einstein theory of relativity, or just express your thanks for the award which has been placed in your hands." I am afraid if I attempted to say anything on Einstein's theory it would involve me in the same trouble as was gotten into by a man who applied for a position and was told he would have to undergo an examination. Some time afterwards he met a friend of his and the friend said, "How did you get on with the examination?" "Oh," he said, "not bad; fifty per cent." "What did they ask you?" "Just two questions." "What were they?" "The first one they asked me was what was the capital of England, and I said, 'New York'. They said that was wrong. The second was to explain in detail all I knew about Einstein's theory of relativity, and I said I didn't know a darn thing about it, and they said that was right."

Mr. President, I am thoroughly and soundly of the opinion that

your nominating committee, in nominating me to get this award, has been more than generous. When I was notified of the award, I took the liberty of scanning over my paper and I came to the conclusion that they exceeded all bounds of generosity.

That puts me in mind of the story of a professor we have up in Toronto. Some of the people in the southern part of your country think that we go to work in the morning with snowshoes, with a fur coat, on the 4th of July, with the temperature over 100°. But this fellow was known throughout his career as having flunked only one man in his final examination. He was asked how it came about that that was so, that only one man had failed in his last examination. He said, "Well, the poor fellow wrote a paper and his answer to the last question was, 'I don't know a damn thing about it,' " and he said, "I would have passed him at that, if he had only spelled the word 'damn' correctly."

I am reminded of the great difference between what your chairman has said and what was said by the chairman of a meeting which I attended a few years ago. It was a dinner meeting, to be addressed by a very well known after-dinner speaker, and the chairman took full advantage of the situation and made a very long introduction, telling everything about the speaker. The crowd grew restless and started shuffling their feet, but he went on. Finally he succeeded in introducing the speaker, who got a tremendous reception, because the man had finished speaking. He got up and said, "Mr. Chairman, I have listened with considerable interest to what you have said. The applause was loud and spontaneous when I got on my feet, and it is evidence to me of a certain sense of relief—so much so that I am in great doubt as to whether it is due to your sitting down or my getting up."

A person at the dinner tonight told me two stories that I would like to tell, so that if there is something wrong with them, she must accept the responsibility. One is of a Scotchman, who was taken to a hospital, where the nurse was fixing him up, and she said to him, "Have you got pajamas?" And he said, "I don't know whether I have or not. They told me the last place it was appendicitis."

In the old days it was the habit of banks in Canada to keep an agent in Scotland, whose duty it was to pick up likely young

Scotchmen for the banking business in Canada. One of them came out with a magnificent salary of $1,000 a year and, at the end of the first year, the bank manager was greatly exercised over the fact that he had a bank balance of $900. He gave directions to bring the boy in and ask him if it was a fact that he saved $900 out of a $1,000 salary. Now, this is a good story of Scotch thrift. You may not believe it but it is true. He brought the boy into his room and asked him if that was the case. He said, "Yes, I saved $900 out of my first year's salary of $1,000." He said, "How did you do that?" "Well," he said, "when I left home, my mother gave me two suits of underwear and one of clothing, so that I didn't have to buy any clothing. I got a room over a baker's shop, where I did not need to pay any rent. I did not have to pay anything for electric light, because there was a street lamp out in front of my window, and I just want to tell you, Mr. Banker, that if it hadn't been for my guts, I would have saved the whole $1,000."

If I may be serious for a minute, I want to say that I do not consider that this Dexter Brackett Medal has been conferred upon me as an individual, but I prefer to look upon it as just a symbol of association between the Canadian and American engineers. We are working hand in hand with those of you on this side of the border —that great invisible border line, extending from the Atlantic to the Pacific, with 1,000 miles of river, 1,000 miles of lake, 1,000 miles of prairie and 1,000 miles of mountain. What a magnificent example to the other nations of the world!

So, Mr. Chairman and President, I prefer to take this honor back to Canada as an evidence from you that you think that the Canadian engineers have done some magnificent work in the fascinating field of public-health engineering, and they will appreciate the honor which you have conferred upon me—I being honored by the memorial to a man who did so much and was such an outstanding engineer in this part of the country. I thank you, one and all.

* * *

Twenty-five Year Certificates were awarded to the following members of the Association: Walter F. Garland, Superintendent of the Dracut Water Supply District, Dracut, Mass.; William P. Melley, Superintendent of the Water Department, Milton, Mass.; Daniel M.

Sullivan, Division Engineer and Deputy Commissioner, Public Works Department, Boston, Mass.; Roger W. Armstrong (retired), Basking Ridge, N. J. (formerly District Engineer, Board of Water Supply, New York, N. Y.); August V. Graf, Chief Chemical Engineer, Water Works, St. Louis, Mo.; A. H. McDonald, Superintendent, Water Department, Littleton, Mass., and Oren McK. Moulton, Engineer, Brookline, Mass.

Friday, September 17

Morning Session

President Donald C. Calderwood in the Chair.

Secretary Knox announced the election of the following to membership in the Association:

James E. Barry, Water Commissioner, Holyoke, Mass.; Wilfred C. Gilbert, Senior Sanitary Engineer, State Department of Health, Concord, N. H.; James D. Halwarts, Assistant Superintendent, Water Dept., Winchester, Mass.; Frank W. Melcher, Water Purification Chemist, Coca-Cola Co., Atlanta, Ga.; George F. Miller, Town Manager, Brattleboro, Vt.; Leopold J. Paradis, Superintendent, Water Dept., Willimantic, Conn.; Edward J. Pinkul, District Engineer, Water Division, Public Works Dept., Boston, Mass.; Martin J. Shaughnessy, Superintendent, Water Dept., Springfield, Mass.; Henry C. Whitlock, City Engineer, Waterbury, Conn.; John P. Sullivan, Engineer, Water Division, Public Works Dept., Boston, Mass.; Arthur S. Hicks, Cons. Water Works Engineer, Dresser Mfg. Div., Dresser Industries, Inc., Bradford, Pa.

Juniors: Russell H. Babcock, Engineer, Whitman & Howard, Boston, Mass.; Walter M. Bussalori, Jr., Student, School of Public Health, Univ. of Massachusetts, Springfield, Mass.

Associates: The Permutit Co., New York, N. Y.; Smith-Blair, Inc., So. San Francisco, Cal.

Corporate Member: The Avon Water Co., Avon, Conn.

A paper on "Solving a Difficult Clarification Problem at Kennebunk, Maine," prepared by F. Smith and M. Lane, Technical Department, Liquid Conditioning Corp., Linden, N. J., was presented by V. J. Calise of the Liquid Conditioning Corp.

A paper on "Modern Equipment in Water Works" was read by Roger W. Esty, Superintendent, Water and Sewer Works, Danvers, Mass.

PRESIDENT CALDERWOOD. It is nearly twelve o'clock, just lacking four or five minutes, and I think it would be well to go on with the next part of the program, which is the closing part. Therefore, at this time I shall call on Mr. Beane for the report of the tellers.

Sydney C. Beane submitted the following:

REPORT OF THE TELLERS OF ELECTION

Total votes cast	312
For PRESIDENT: Arthur C. King	310
For VICE-PRESIDENT: Gordon M. Fair	307
For DIRECTOR: Frederick O. A. Almquist	307
For TREASURER: William P. Melley	310

(*Signed*) SYDNEY C. BEANE
THOMAS S. LAWRENCE
WALTER C. CONROY

PRESIDENT CALDERWOOD. You have elected as president, Arthur C. King; as vice-president, Gordon M. Fair; as director, Frederick O. A. Almquist; and as treasurer, William P. Melley.

Now, as it is customary at this time for the retiring president to make a few remarks, I shall comply with the custom and then my duties as your president will be over.

PRESIDENTIAL ADDRESS

BY DONALD C. CALDERWOOD

Our Sixty-seventh Annual Convention is rapidly drawing to a close and soon we shall be leaving New York for our own communities. As your thoughts turn towards home, there is one special thought I should like to have you take along with you, and that is: Be foresighted in this, our water-works industry.

During World War II, considerable emphasis was directed towards "Blueprint Now," a program whereby plans were made for developments and construction during the depression period, which

nearly everyone predicted would visit us during the transition from war to peace. V-J Day occurred over three years ago and the predicted depression has failed to materialize. In fact, in its place a period of inflation has plagued us.

In many departments it has been impossible to keep up with demands for new services and extensions into newly developed areas. Because of this unprecedented demand for new services, with its accompanying difficulties in obtaining manpower, materials and supplies, most communities have been unable to give any thought to a long-range program of development, to say nothing of taking definite steps towards its installation.

Water is the one commodity and service that modern civilization cannot do without. It not only serves as our food and drink, but it is also the guardian of our health and property. Cut off the water supply from any community for a few hours and the doors are left open for the loss of our property by a conflagration or, worse still, the loss of life through an epidemic brought on by the accumulation of filth. We, as water-works men, must accept these facts and, through our foresightedness, must do everything to make it possible for the water systems in our communities to meet whatever demands may be placed upon them.

During World War II the average superintendent found it impossible to make additions to his plant, such as new pumping equipment, filter plants, or the development of additional supply capacity. New industrial and residential growth, as well as improvements in our standards of living, requires additional amounts of water. In this category you must include such technical developments as air conditioning, since this requires large amounts of water during the hot, dry weather, which usually coincides with the period of greatest demand on most systems.

We have been fortunate, inasmuch as nature herself has already given us some rough yardsticks to measure the adequacy of our plants. Last summer, New England experienced the most severe drought of short duration ever to be recorded in this area. This gave us one yardstick to measure the adequacy of our source of supply. If during this drought period your source of supply was not depleted and you still had sufficient reserve, in all probability you should have

no worries over the adequacy of your supply for several years to come.

Only last month the most severe heat wave on record hit New England. Home owners, in an attempt to get relief from the oppressive heat, dug out the garden hose to wet down the buildings and the grounds around them. Air-conditioning equipment in theaters, factories, offices and stores was operated on an around-the-clock basis, and the daily demand on many systems jumped to two or three times the normal. If during this period of excessive demand the pressure in your distribution system remained at or near normal, if the water level in your distribution reservoirs could be held at or near the full mark, and if you still had adequate pumping reserve, you should breathe a sigh of relief, because many of your fellow superintendents were not so fortunate.

If your plants meet the requirements of the above yardsticks, you or your predecessors built wisely and well. If your plants do not measure up to these present-day standards, they may still have built wisely and well, but the day has arrived when you must take account of stock and make such additions and changes as may be necessary to meet these increased demands. Your communities look to you to guide them and lead them along the paths of safety. That is your duty. With the tradition of the real water-works man behind you, we know that you will not fail.

It has been a pleasure and a great honor to serve as your President during the past year, but a President by himself has little control over the destiny of an organization such as this. The members of the Executive Committee, the various committee members and you, as active members, decide and determine by your actions if the year is to be a successful one.

Special recognition must be made of the work done by our Secretary, Joseph C. Knox; Treasurer, William P. Melley; Editor, George C. Houser; Program Committee Chairman, Stanley M. Dore, and Assistant Secretary, Mrs. Alice Melrose. Few realize the hours of labor and effort they put in to keep the wheels of our organization turning smoothly.

In behalf of the New England Water Works Association, I also wish to express appreciation to the members of the Water and Sewage

Works Manufacturers Association, Inc., for the work they have done in making our social programs so successful.

I know that this spirit of coöperation and willingness to work for our association will continue.

Apropos of "building wisely and well for the future," just 38 years ago one of our past executives in the New England Water Works Association did just that, because today his son is following in his father's footsteps and they lead him directly to the presidency of our organization. This is the first time in the history of the New England Water Works Association that this honor has been conferred upon both father and son.

I now extend my congratulations and best wishes to our new President, Mr. Arthur C. King. Fellow members, we now have a King for President.

PRESIDENT KING. Now I know how a pancake feels when the syrup is poured over it.

Seriously, I deeply appreciate this honor that has been bestowed upon me and I shall, I assure you, do my best to uphold the traditions of this old and honorable association—old but ever new with the addition of new members, as some of us oldtimers pass out of active participation, as I realize that I am becoming one of the oldtimers now, after 41 years in the association. But at the same time I want to remind you, each and every one, that I want your coöperation and your help. It is just as much your association as it is mine. Let us all work together and make the old New England Water Works Association, as it has always been, a great organization.

I thank you.

If there is no further business anyone has to bring up at this time, I believe the time has come for the closing of this Sixty-seventh Annual Meeting of the New England Water Works Association.

[*Adjourned*]

ANNUAL REPORT OF THE SECRETARY

Mr. President and Gentlemen of the New England Water Works Association: The Secretary herewith submits the following report of the changes of membership during the past fiscal year and the general condition of the Association.

The present membership is 898, constituted as follows: 10 Honorary Members, 739 Members, 118 Associate Members and 31 Corporate Members.

MEMBERSHIP

				Total
September 1, 1947—Honorary Members, Total				10
September 1, 1947—Members, Total		711		
Withdrawals:				
Resigned	12			
Died	7			
Dropped by Executive Committee	18	37	674	
Elected:				
September 15, 1947	30			
September 16, 1947	3			
October 16, 1947	6			
November 20, 1947	1			
December 18, 1947	5			
January 15, 1948	4			
February 19, 1948	6			
March 18, 1948	3			
April 21, 1948	4			
May 20, 1948	1			
June 10, 1948	1			
Junior Member elected Feb. 19, 1948	1		65	739
September 1, 1947—Associates, Total		116		
Withdrawals:				
Resigned	3			
Dropped by Executive Committee	1	4	112	

Elected:				
September 15, 1947	3			
October 16, 1947	1			
December 18, 1947	1			
June 10, 1948	1		6	118
September 1, 1947—Corporates, Total		28		
Elected:				
February 19, 1948	2			
March 18, 1948	1	3		31
September 1, 1948—Total Membership				898
September 1, 1947—Total Membership				865
Net Gain				33

ELECTIONS

Members

September 15, 1947—Gordon A. Barker, John T. Barnhill, Harold W. Blake, Ivan A. Buchanan, William M. Burns, Eugene R. Davis, Terrance J. Durant, Frederick A. Cole, Carl A. Ellis, Edward A. Farmer, Edward A. Graustein, John H. Harding, Stephen Haseltine, J. Wilbur Irish, Malcolm G. Keniston, Henry A. Kingsbury, John P. Lynch, Ira P. Macnab, Regina L. Martineau, William H. McGuinness, Robert W. Muther, Jr., Edgar F. Orpin, Mohammad A. Rehmann, Lincoln W. Ryder, Frederick B. Silliman, John R. Snell, E. Warren Ward, William L. Wenzel, George S. Wescott and Clarence Wickerson. (30)

September 16, 1947—Fred E. Colby, James L. Dallas and Carroll F. Pritham. (3)

October 16, 1947—Frank B. Crowley, John J. Desmond, Calvin K. Glover, John F. Kelly, George H. Shea and John H. White. (6)

November 20, 1947—Edward J. Kelley. (1)

December 18, 1947—John S. Capaldi, R. Nelson Molt, Walter L. Olson, Richard O'Neill and William A. D. Wurts. (5)

January 15, 1948—William H. Balke, Jr., J. Elliott Hale, Harry W. Lea and Cecil W. Mann. (4)

February 19, 1948—Alfred W. Albert, Elmer W. Campbell, Ray L. Derby, Roger P. Disken, Samuel Jacobson and George M. Mathews. (6)

March 18, 1948—Roy O. Leonard, Dr. Enrique Lilue and Julius A. Nido. (3)

April 21, 1948—John H. Barr, Clifford R. Greenough, Earle L. Pike and Edwin Rothman. (4)

May 20, 1948—Charles I. Lucas. (1)

June 10, 1948—Werner N. Grune. (1)

Associate Members

September 15, 1947—Albert Pipe Company, Inc., Ozone Processes Division, Andres Rozlosnik. (3)
October 16, 1947—Trafton Filters Company. (1)
December 18, 1947—Bowser, Incorporated. (1)
June 10, 1948—Joseph G. Pollard Company, Inc. (1)

Corporate Members

February 19, 1948—Norfolk, Mass., Board of Water Commissioners and Rumford and Mexico, Maine, Water District. (2)
March 18, 1948—Leicester Water Supply District. (1)

Junior Members

February 19, 1948—Syed I. Husain. (1)

WITHDRAWALS

Members

Resigned: Frederick F. Aldridge, Gerald H. Davis, Harvey W. L. Doane, Raymond F. Goudey, Frank D. Lord, Morrison Merrill, Marvin C. Nichols, Charles L. Pool, John H. Robinson, M. Irving Sprague, Harold J. Stewart and A. B. Thompson. (12)
Died: Alfred O. Doane, Edwin A. Fisher, James E. Gibson, Joseph A. Hoy, William S. Lea, John W. Moran and Michael E. Quirk. (7)
Dropped by Executive Committee: Elwood L. Bean, John T. Broderick, Carl E. Chapman, James S. Goff, George L. Hathaway, Walter H. Hatch, Deane E. Hawkins, Eugene C. Heacox, John F. Kenny, Harrison E. Miles, Charles H. Morey, Jr., Henry F. O'Connell, Frederick C. Penniman, Ellsworth A. Richardson, Lewis C. Sanborn, Kenneth F. Thompson, Harold C. White and Robert L. Wiley. (18)

Associates

Resigned: American Smelting and Refining Company, Green Rubber Company and Johnson, Barker and Webb Company. (3)
Dropped by Executive Committee: Norwood Manufacturing Engineering Company. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1947, TO SEPTEMBER 1, 1948

Entrance Fees	$ 234.00
Dues of All Grades of Members	6,649.50
Dividends	495.36
Advertisements	5,377.63
Subscriptions	636.40
Journals	216.42
Membership Certificates	38.00
Membership Lists	2.50
Total Receipts	$13,649.81
There is due the Association:	
Dues	142.00
Total	$13,791.81

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

ANNUAL REPORT OF THE TREASURER

Boston, September 8, 1948

To William P. Melley, Treasurer,
New England Water Works Association,
Boston, Massachusetts.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the fiscal year ended August 31, 1948, have reviewed the accounting procedures of the association and have examined accounting records of the association and other supporting evidence, by methods and to the extent we deemed appropriate.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1948, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in savings banks, and on September 2, 1948, we examined the United States Treasury savings bonds at the First National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related statement of cash receipts and disbursements of the general fund present fairly the position of the New England Water Works Association at August 31, 1948, and the recorded cash receipts and disbursements for the fiscal year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (EXHIBIT A)
As at August 31, 1948

Assets

Cash in Banks, Invested Funds		
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	$ 1,068.46	
Franklin Savings Bank, Boston, Massachusetts	1,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	1,000.00	
Home Savings Bank, Boston, Massachusetts	1,000.00	
Mechanics Savings Bank, Reading, Massachusetts	1,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	1,000.00	
The People's Savings Bank, Worcester, Massachusetts	1,000.00	
Suffolk Savings Bank, Boston, Massachusetts	1,000.00	$ 8,068.46
Securities		
U. S. Treasury Savings Bonds G 2½s, 1954	$10,000.00	
25 Shares Milton Co-operative Bank, Series of June, 1940	2,886.50	12,886.50
Total Invested Cash and Securities		$20,954.96
General Fund		
Cash, First National Bank of Boston	$ 5,420.62	
In office	50.00	
	$ 5,470.62	
Furniture and fixtures	1,180.00	6,650.62
		$27,605.58

Funds

Invested Funds		$20,954.96
General Fund		
Balance, August 31, 1947	$ 5,679.85	
Deduct Purchase of Milton Co-operative Bank Shares	300.00	
	$ 5,379.85	
Add Excess of Receipts over Disbursements, Exhibit B	1,270.77	
Balance, August 31, 1948		6,650.62
		$27,605.58

Note: The statement above, prepared on a cash basis, includes dues received in advance, $2,582, and employees' withholding tax, $58.38. It does not reflect the following:

Accounts receivable, dues	$ 142.00

No depreciation has been taken on furniture and fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (EXHIBIT B)

General Fund

For the Year ended August 31, 1948

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation fees		$ 234.00	
Dues, 1947-1948 and prior years		4,067.50	
Interest		495.36	
From publication of Journal			
Advertisements	$5,377.63		
Subscriptions	636.40		
Sale of Journal	216.42	6,230.45	
Miscellaneous			
Membership certificates	$ 38.00		
Membership lists	2.50	40.50	
Total Receipts			$11,067.81
Disbursements			
Publication of Journal			
Printing	$2,854.48		
Plates	91.62		
Reprints	394.55		
Reporting	270.80		
Stationery and postage	81.58		
Editor's salary	500.00		
Sundry	46.61	$4,239.64	
General and Administrative			
Certificates of membership	$ 25.52		
Secretary's salary	500.00		
Assistant to secretary—salary	2,184.00		
Treasurer's salary	100.00		
Printing, postage and stationery	350.71		
Office supplies and expense	540.97		

Office rent	1,240.00		
Electricity	78.21		
Telephone and telegraph	193.04		
Auditing	85.00		
Social security taxes	46.67		
Moving expense	119.51		
Sundry	56.07	5,519.70	
Meetings and Committees			
Water works school	$ 125.00		
Printing, postage and stationery	886.45		
Convention expense	503.11		
Dinners	727.89		
Contribution to June conference	150.00		
Sundry expense	122.89	2,515.34	
Interest added to co-operative bank shares		91.50	
Total Disbursements			$12,366.18
Excess of disbursements over receipts (exclusive of dues received in advance and employees' withholding tax for current year)			$1,298.37
Dues received in advance		$2,582.00	
Employees' withholding tax			
Payment for prior year	$71.24		
Less receipts for current year	58.38	12.86	2,569.14
Excess of receipts over disbursements, Exhibit A			$1,270.77
Balance, General Cash, August 31, 1947		$4,499.85	
Less purchase of Milton Co-operative Bank shares		300.00	4,199.85
Balance, General Cash, August 31, 1948			
Represented by			
Cash in First National Bank of Boston		$5,420.62	
Cash in office		50.00	
			$5,470.62

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith his report for the year ending August 31, 1948.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received and disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1947, and March and June, 1948, issues of the JOURNAL is included in the report of the Treasurer.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1947, AND MARCH AND JUNE, 1948, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

	Papers	Proceedings*	Total text	Index	Advertisements	Cover and contents	Insert plates	Total pages	Total cuts
Sept., 1947	68	37	105	0	44	4	1	154	8
Dec., 1947	43	59	102	9	44	4	0	159	14
Mar., 1948	98	4	102	0	45	4	0	151	14
June, 1948	84	18	102	0	45	4	0	151	0
Total	293	118	411	9	178	16	1	615	36

*Including standard specifications.

Size. The four issues contained 615 pages, of which 411 were text.

Cost. The gross cost of the JOURNAL was $4,239.64, equivalent to $4.84 per member; the surplus was $1,990.81, equivalent to $2.28 per member.

TABLE 2.—COMPARISON OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION
Four Issues for Fiscal Year Ending August 31

	1939	1940	1941[1]	1942[2]	1943[3]	1944	1945	1946	1947	1948[4]
Average edition (copies printed)	1,100	1,100	1,100	1,100	1,175	1,200	1,200	1,200	1,275	1,350
Average membership	795	796	800	803	798	799	806	820	846	876
Circulation at end of year	946	967	943	982	969	1,015	1,032	1,042	1,083	1,129
Pages of text	488	565	540	575	442	442	438	391	428	411
Pages of text per 1,000 members	614	710	675	716	554	553	543	477	516	469
Total pages, all kinds	670	762	733	757	616	621	630	586	632	615
Total pages per 1,000 members	843	957	918	943	772	777	782	715	747	702
GROSS COST:										
Total	$4,119.30	$3,846.46	$4,415.00	$4,053.47	$4,234.68	$3,406.48	$3,734.19	$4,053.08	$4,193.60	$4,239.64
Per copy	0.94	0.87	1.00	0.93	0.90	0.71	0.78	0.84	0.82	0.78
Per page	6.15	5.05	5.66	5.36	6.87	5.49	5.83	6.91	6.63	6.90
Per member	5.18	4.33	5.52	5.05	5.31	4.26	4.63	4.94	4.96	4.84
Per member per 1,000 pages	7.13	6.34	7.53	6.67	8.61	6.87	7.35	8.43	7.85	7.87
Per member per 1,000 pages of text	10.61	8.55	10.21	8.78	12.01	9.66	10.57	12.62	11.58	11.78
SURPLUS:										
Total	$306.77	$618.37	$276.54†	$534.72†	$609.81†	$407.21	$455.57	$162.33	$913.91	$1,990.81
Per copy	0.07	0.14	0.06†	0.12†	0.13†	0.08	0.09	0.03	0.18	0.37
Per page	0.46	0.81	0.38†	0.71†	0.99†	0.66	0.72	0.28	1.44	3.32
Per member	0.39	0.78	0.35†	0.67†	0.76†	0.51	0.57	0.20	1.08	2.28
Per member per 1,000 pages	0.58	1.02	0.47†	0.88†	1.24†	0.82	0.90	0.34	1.71	3.71
Per member per 1,000 pages of text	0.80	1.37	0.64†	1.16†	1.73†	0.92	1.29	0.51	2.52	5.55

[1]Including comprehensive index, 1882 to 1939, and 102 pages of standard specifications.
[2]Including 45 pages of standard specifications.
[3]Including 28 pages of standard specifications.
[4]Including 54 pages of standard specifications.
†Net cost.

Reprints. Reprints of papers have been furnished to authors at cost.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	888
Subscribers	155
Exchanges	23
Advertisers	63
Total	1,129

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER,
Editor

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 31, 1948

To the Executive Committee of the New England Water Works Association

GENTLEMEN:

Your Finance Committee herewith presents its report on the budget for the year 1947-1948 and its recommended budget for the year 1948-1949.

The Committee has met with the Treasurer and reviewed his figures.

During the past year the following changes have taken place in the membership roster:

	Resigned	Deaths	Dropped	Additions	Gain
Members	12	7	18	64	27
Corporates	0	0	0	3	3
Associates	3	0	1	6	2
Juniors	0	0	0	1	1
Totals	15	7	19	74	33

While slightly below last year's exceptional figure of 39, the gain in membership continued gratifyingly high, making a total of 898. A note of interest might be added here that 91 members are exempt from dues because of length of membership.

The following tables show the estimated and actual budget figures for 1947-1948:

REVENUE FOR 1947-1948

	Budget	Actual to Aug. 31	Difference
Initiation Fees	$ 200.00	$ 234.00	$ 34.00 balance
Dues	6,400.00	6,649.50	249.50 balance
Interest and Dividends	375.00	495.36	120.36 balance
Journal	5,800.00	6,230.45	430.45 balance
Miscellaneous	75.00	40.50	34.50 deficit
Total	$12,850.00	$13,649.81	$799.81

EXPENDITURES FOR 1947-1948

	Budget	Actual to Aug. 31	Difference
General and Administrative	$6,200.00	$5,532.56	$667.44 balance
Journal	4,500.00	4,239.64	260.36 balance
Meetings and Committees	2,000.00	2,515.34	515.34 deficit
Contingencies	500.00	91.50	408.50 balance
Total	$13,200.00	$12,379.04	$820.96

The increase in actual over estimated revenue was due mainly to the new advertising rates in the JOURNAL and an increase in membership. The total revenue exceeded the disbursements by $1,270.77.

Your Committee recommends continuing the policy of an unbalanced budget, due to prevalent economic conditions and probable increases in costs.

BUDGET FOR 1948-1949

Revenue

Initiation Fees	$ 200.00
Dues	6,500.00
Interest and Dividends	400.00
Journal	6,200.00
Miscellaneous	100.00
Total	$13,400.00

Expenditures

General and Administrative	$ 6,300.00
Journal	4,500.00
Meetings and Committees	3,200.00
Contingencies	1,000.00
Total	$15,000.00

The revenue items listed above are practically the same as last year. Under "Expenditures", the increase under the item "General and Administrative" is due to anticipated increased expenses and necessary office equipment. Under the item "Meetings and Committees", the increase is due to the difference between receipts and costs of the dinners at the monthly meetings.

The reserve on hand August 31 amounts to $27,605.58 as compared with $24,243.31 last year:

Checking Account and Petty Cash	$ 5,470.62
Furniture and Fixtures	1,180.00
Bonds	10,000.00
Savings Account	8,068.46
Serial Shares	2,886.50
	$27,605.58

We refer you to the Treasurer's Report for further details.

As can be seen, the Reserve Fund is still increasing and we still have the problem of how best to make use of this for the benefit of the Association. We offer the suggestion that consideration be given to the advisability of the Association's sponsoring a "water-works short course", as was done once before and is being done with great success in other sections of the country.

Respectfully submitted,

(*Signed*) KENNETH W. ROBIE, *Chairman*
WALTER C. CONROY
JOHN B. KENNEDY

ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

September 14, 1948

To the New England Water Works Association:

Your Committee on Legislation presents the following report on activity in the State Legislatures in 1948.

There were no regular sessions held this year in New England, except in Massachusetts, so this report will be largely from that State, with mention of action at a special session in Connecticut, which amended the sales and use tax. The tax was reduced to 1% until July 1, 1949, when it becomes 2%. An amendment to the existing law grants exemption from tax for "Sales of and the storage, use or other consumption of materials, tools and fuel or any substitute thereof, but excluding machinery or replacement parts thereof, when such products are used and consumed directly in the furnishing of power to an industrial manufacturing plant or the furnishing of gas, water, steam or electricity when delivering to consumers through mains, lines or pipes". It is to be noted that products must not only be used but must also be consumed in order to be exempt.

In Massachusetts, your committee, acting upon instructions from the Executive Committee, presented a petition to the General Court, Senate Bill No. 417. The legislative committee on Water Supply, after a hearing at which several members of this Association spoke, favored the passage of this bill, but suggested study by a Recess Commission. This thought was approved by all concerned and the Commission has been appointed and has organized, with Senator Lerch of Northampton, Chairman, Representative Wood of Hopkinton, Co-Chairman, Representatives Driscoll of Boston and Sanderson of Marblehead, with three members of this Association appointed by Governor Bradford—namely, Peter C. Karalekas of Springfield, Frank P. Morse of Salem and the chairman of your Committee on Legislation. Hearings are to be held throughout the State, preceded by complete notice to water-works officials as well as to Mayors and Selectmen.

The intent of this bill is to hold water-works revenue for water-works use and to legalize a business-like accounting by which municipal water systems can pay their expenses, including taxes, receive

payment for services rendered and maintain service without excessive periods of financial starvation, or abundance which may be drawn off for other uses. The payment of taxes, or an equivalent, will give some income to the general treasury, the amount, or the basis of computation, being one of the subjects for study and discussion. The holding of surplus income in a depreciation or reserve fund, as is now done by special act in some cases, will tend to stabilize the relation between water-works income and the general treasury. A reserve fund built up in advance will reduce the interest charges on bond issues now necessary for extensions and replacements.

We have discussed this bill at some length, because we feel that it is of much importance and that all water-works men in Massachusetts should do their utmost to convince their city and town officials, as well as their legislators, of the value of the bill which we expect to develop and present to the 1949 session of the General Court. It is the belief that the State Director of Accounts will assist rather than oppose this legislation.

A step in the same direction was taken by the legislation enacted this year regarding the Fitchburg Water Works, as Chapter 234 of the Acts of 1948. The act established the water department as a unit separate from the department of public works, with the registrar becoming the commissioner, in full charge, subject to approval of the Mayor and the Council. The act provides also for the holding of any surplus of income over expenses to be used for water-works purposes. This act is subject to acceptance by referendum vote in Fitchburg this fall.

In spite of considerable opposition by water-works men at the hearing, a bill was enacted into law forbidding the use of inflammable fluid as an anti-freeze mixture in hydrants used to convey water for extinguishing fires.

Respectfully submitted,

(*Signed*) ARTHUR C. KING, *Chairman*
THEODORE L. BRISTOL
WALTER C. CONROY
MARK F. CROKER
G. ARTHUR FANEUF
HARRY U. FULLER
PHILIP J. HOLTON, JR.
EDWARD L. TRACY

ANNUAL REPORT OF COMMITTEE ON COMMITTEES—1948

To the New England Water Works Association:

This committee, appointed by the Executive Committee of the Association to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable, submits the following report. Our committee has followed its usual practice of communicating with the various committee chairmen to ascertain their ideas as to continuance of committees and their plans with regard to reports. We have also checked up during the year with other associations regarding joint committees. The Technical Program Committee has been advised as to those committees desiring to submit reports at the annual meeting.

Committee activity was of necessity curtailed during the war; it now appears that inactive committees should be dispensed with. There are some joint committees with other associations, however, dealing with preparation and approval of certain standards, where progress may be unavoidably slow in getting out reports. In writing to committee chairmen this year, this committee stressed the desire of the Executive Committee to weed out inactive committees.

During the year, no new committees were appointed by the Executive Committee. Some changes were made, as usual, in committee membership, as noted in the December, 1947, JOURNAL of the Association.

Listed below are committees which, in the opinion of this committee, should be continued, together with some notations as to activities where information is available through the committee chairmen. In the case of all the following committees, the committee chairmen have expressed the opinion that the committees should be continued:

*Committee on Technical Program.
*Committee on Finance.
*Committee on Membership.
*Committee on Library.

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*Expects to submit report at 1948 annual meeting.

*Committee on Committees.
*Committee on Legislation.
*Committee on Reciprocal Relations with the Institution of Water Engineers.
Committee on Classification of Water Works Employees and Salaries. Expects to undertake study next year.
**Committee on Survey of Ground Water Supplies in New England.
**Committee on Rainfall and Yield of Drainage Areas.
**Committee on Distribution System Safety. (Joint Committee with A.W.W.A.)
Committee on Cathodic Protection of Steel Tanks and Standpipes. Experiments are proceeding and report is expected in 1949.
Committee on Coëfficients for Friction in Pipe Lines. No report is planned. This committee has done outstanding work and it should be continued if the committee plans to report on further developments.
Committee to Investigate Grounding. (Coöperating with the American Research Committee on Grounding.) This committee plans to submit no report but has matters under consideration.
Committee on Water Quality Tolerances for Industrial Uses. This committee is at work and plans to submit report in 1949.
Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation. This committee is at work and plans to submit report in 1949.
**Committee on Specifications for Cast-Iron Pipe and Special Castings. (Sectional Committee under A.S.A.)
**Committee on Reinforced Concrete Pressure Pipe. (Joint Committee with A.W.W.A.)
**Committee on Code for Pressure Piping. (Joint Committee with A.S.M.E.)
**Committee on Laying Cast-Iron Pipe. (Joint Committee with A.W.W.A.)
**Committee on Specifications for Steel Pipe. (Joint Committee with A.W.W.A.)

**Expects to submit progress report at 1948 annual meeting.

Committee on Standardization of Pipe Flanges and Fittings. (Sectional Committee under A.S.A.) No report is apparently to be submitted, but it would seem that the committee should be continued until its work has been reported completed.

Committee on Valve Box Frames and Covers. (Joint Committee with A.W.W.A.) Committee will submit a report if ready.

**Committee on Meter Specifications. (Joint Committee with A.W.W.A.)

*Committee on Hydrant Specifications. (Joint Committee with A.W.W.A.) Committee may complete its work in another year. It hopes to submit semi-final report in 1948.

**Committee on Gate Valves. (Joint Committee with A.W.W.A.)

Committee on Sluice Gates. (Coöperating with A.W.W.A.) This committee is apparently not planning to submit a report but undoubtedly should be continued.

Committee on Threads for Underground Service Line Fittings. (Joint Committee with A.W.W.A.) This committee expects to be able to submit a final report at the 1948 annual meeting and may recommend its discontinuance.

Committee on Steel Standpipes and Elevated Tanks. (Joint Committee with A.W.W.A.) This committee will submit no report, but revisions of rules for field welding on steel storage tanks are under way.

Replacement of Committee

Committee to Report on Developments in Water Quality. The chairman of this committee suggests the possibility that this be made a joint committee through arrangement with the American Water Works Association, which now has a "Committee on Biological and Chemical Problems of Water Distribution Systems", of which the chairman of this N.E. W.W.A. committee is a member. It is suggested that our association through its secretary consult with the secretary of the American Water Works Association on this matter.

New Committees

Last year no new committees were appointed. Consideration was given to the establishment of a committee on labor-management rela-

tions but, due to lack of interest in securing committee membership to promote the activity, the idea was given up. A suggestion has been made that procedures for water-rate increases be made a basis for committee study, but it was decided for the present to endeavor to promote presentation of one or more papers on this subject.

Our committee recommended last year that a committee be designated to report to the Executive Committee on a program of public education in the water-supply field, either through paid expert service or in some other way. We pointed out that other associations are finding that such activities pay dividends in public good-will and support. The Executive Committee subsequently secured proposals from several public relations managers but did not feel the proposed expenditures would be warranted. Our committee still is of the opinion that further steps could and should be taken. As a suggestion, it is proposed that the Executive Committee appoint a committee to bring in some concrete proposals as to what might be done to:

1. Send out news-letters on water-works activities and developments to local water officials, which they might release to local newspapers.
2. Increase coverage of monthly meetings by reports to the press in "newsy" style.
3. Increase coverage of annual meetings by reports to the convention-city press and other press agencies.

Some of this might be done by employing an interested water-works man on a small part-time basis to work with association headquarters.

Conclusions and Recommendations

It is recommended that the standing committees listed above be re-appointed and that the replacement of one committee, listed separately, be considered. A recommendation as to public education in the water-supply field through initial committee action is presented and should, in our opinion, be adopted.

Respectfully submitted,

(*Signed*) WARREN J. SCOTT, *Chairman*
HARRY U. FULLER
ARTHUR C. KING
EARL R. PERRY
WILLIAM E. STANLEY

REPORT OF COMMITTEE ON TECHNICAL PROGRAM

To the New England Water Works Association:

Your committee has presented a program of technical papers for meetings during the year, including those for the annual meeting in New York, for the afternoon sessions, the chemists' round table and the superintendents' round table at monthly meetings in Boston, and for the outing meetings in Dover and Swampscott, as well as a lecturer at the Water Works School.

In accordance with the desires of your President and others, efforts were made to secure papers by members, particularly superintendents and operators. These efforts met with some degree of success and the papers were well received. It is recommended that superintendents and operators be encouraged to present more papers at the *afternoon sessions*. A feeling exists among some that the subject matters of papers they can prepare are not important enough for formal presentation at such sessions, but your committee has found that the society members are very much interested in the problems of operation and maintenance, and that novel and original ways of meeting these problems make excellent subject matter for short papers, even though the dimensions of the individual problem might seem comparatively small to the speaker.

This year, your committee was requested to furnish a technical paper for the outing meeting in June. It is recommended that no such request be made for subsequent, like outing meetings, as the attendance is comparatively very small, and your committee feels that it is not warranted in requesting a speaker to prepare and present a paper to an audience of inadequate number for the announced purpose of having an advertised technical paper.

All members of your committee have coöperated in the suggestion of program and papers and in the securing of speakers. The Association has no budget for the payment of expenses incurred by the speakers for preparation or for travel, so that your committee must rely almost wholly upon the willingness of its members for the con-

duct of satisfactory programs, and the large majority of its members are superintendents, chemists, operators or people in positions connected with management, operation and maintenance of water works.

More enthusiasm in the preparation of short papers on simple everyday problems is urgently suggested as the duty of every member, regardless of his connection with the water-works field, in order that your committee may technically entertain all the members to the best advantage. To do so the committee must obtain, largely through voluntary and unsolicited coöperation of the members, numerous short papers that cover a wide range of interests in the water-works field.

(*Signed*) STANLEY M. DORE, *Chairman*
GEORGE G. BOGREN
WILLIAM B. DUFFY
GORDON M. FAIR
GEORGE C. HOUSER
PAUL F. HOWARD
THOMAS E. KENNEDY
TRUMAN H. SAFFORD
MARSHALL S. WELLINGTON

ANNUAL REPORT OF THE COMMITTEE ON MEMBERSHIP—1948

September 14, 1948

To the New England Water Works Association:

After the officers of the Association were elected for the current year, the President appointed your Chairman of the Committee on Membership, with authority to appoint additional members. Additional members were appointed to represent the several geographical divisions represented in the Association as follows:

MEMBERS OF THE COMMITTEE ON MEMBERSHIP

FRANCIS H. KINGSBURY, *Chairman*	CHARLES J. CRUMP
F. EDWARD DRISCOLL	HOWARD C. MANDELL
WILLIAM J. C. MARSHALL	HOWARD H. POTTER
JAMES A. SWEENEY	ELLIS A. TARLTON
EDWARD L. TRACY	JAMES V. TURNER

This Committee makes the following report:

New Members

	Regular	Junior	Associate	Corporate	Total
	34	1	3	3	41
(Elected Sept. 13, 1948)	11	2	2	1	16
	45	3	5	4	57

Loss of Members

	Regular	Junior	Associate	Corporate	Total
Resigned	12		3		15
Died	7				7
Dropped	18				18
	37		3		40

Net Gains

	8	3	2	4	17

Total membership to date of this report is 915.

Respectfully submitted,

(*Signed*) FRANCIS H. KINGSBURY, *Chairman*

REPORT OF THE COMMITTEE ON LIBRARY

To the New England Water Works Association:

Your Committee Chairman has on several occasions during the past year discussed the disposition of periodicals and other similar matter with Mrs. Melrose and certain suggestions made have been acted upon by the Executive Committee in conserving the shelf space in the new office.

Respectfully submitted,

HARRY L. KINSEL
(*Signed*) KARL R. KENNISON, *Chairman*

FOURTH PROGRESS REPORT OF THE COMMITTEE ON RAINFALL AND YIELD OF WATERSHEDS IN NEW ENGLAND

September 10, 1948

To the New England Water Works Association:

The Committee on Rainfall and Yield of Watersheds in New England, appointed in November, 1938, has made three progress reports dated September 5, 1939, September 24, 1940, and September 25, 1941. The second and third progress reports were published in this JOURNAL, Volume LIX, No. 3. In addition, the records of rainfall in New England were tabulated through the year 1941 and published in this JOURNAL, Volume LVI, No. 4, LVII, No. 1, and LVII, No. 3.

Work is now under way in tabulating the records of rainfall in New England for the years since 1941 and, when this work has been completed, arrangements will be made for the tables to be published. In connection with the diagrams showing the Storage-Yield relations, published in the second and third progress reports, an examination of the rainfall and yield data collected since that time shows that, if the more recent data were included in the calculations, little if any change would be noted in the diagrams, demonstrating that since 1941 there has been no critical dry period sufficient to change the data previously published.

Since the U. S. Geological Survey has collected considerable data on runoff, it has been deemed desirable to compute Storage-Yield relations on certain watersheds, where records have been maintained for a comparatively long period of time. The Storage-Yield relations for two such watersheds have been calculated and are as follows:

1. Housatonic River near Great Barrington, 1913-1944—drainage area, 280 square miles (see Figure 1).
2. Quaboag River at West Brimfield, 1912-1944—drainage area, 151 square miles (see Figure 2).

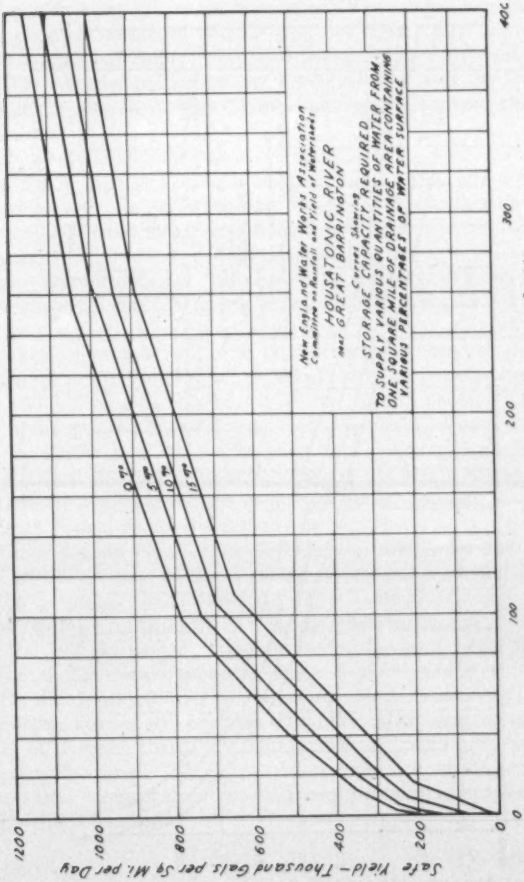
New England Water Works Association
Committee on Rainfall and Yield of Watersheds
HOUSATONIC RIVER
near GREAT BARRINGTON
Cornell Station
STORAGE CAPACITY REQUIRED
TO SUPPLY VARIOUS QUANTITIES OF WATER FROM
ONE SQUARE MILE OF DRAINAGE AREA CONTAINING
VARIOUS PERCENTAGES OF WATER SURFACE
0%
5%
10%
15%
Safe Yield – Thousand Gals per Sq Mi. per Day
Storage – Mil Gals per Sq Mi.
0
200
400
600
800
1000
1200
100
300

FIGURE 1.

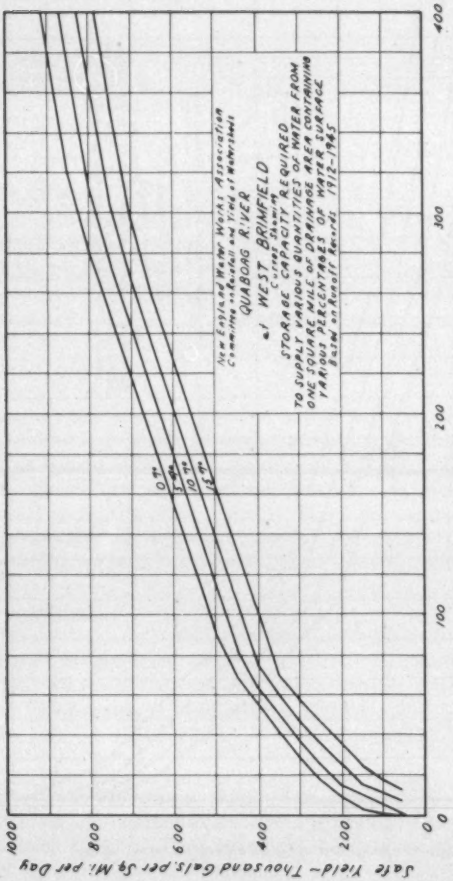
New England Water Works Association
Committee on Sources and Yield of Watersheds
QUABOAG RIVER
at WEST BRIMFIELD
Color Basin
STORAGE CAPACITY REQUIRED
TO SUPPLY VARIOUS QUANTITIES OF WATER FROM
ONE SQUARE MILE DRAINAGE AREA CONTAINING
VARIOUS ACCUMULATED DRAFTS OF WATER SURFACE
Basin Runoff Record 1912-1945
0"
5"
10"
15"
Safe Yield - Thousand Gals. per Sq Mi. per Day
1000
800
600
400
200
0
0
100
200
300
400
Storage - Mil. Gals per Sq Mi.

FIGURE 2.

The critical periods on the Housatonic River near Great Barrington for yields in excess of 800,000 gpd per square mile lie between June, 1929, and November, 1931, and between June, 1929, and October, 1932. An examination of the Tucker Brook and the Tillotson and Hollister Brook studies shows that approximately the same periods are critical.

For yields from 600,000 to 800,000 gpd per square mile, the Tucker Brook critical period is between July, 1910, and February, 1911, while with the Tillotson and Hollister Brook data for yields between 400,000 and 800,000 gpd per square mile, the critical period is between June, 1939, and February, 1940.

Since there are no flow records on the Housatonic River prior to 1913, there might be some question as to whether the 1908-11 period would be a critical period for this stream. However, rainfall records at Pittsfield show that the total rainfall between July 1, 1910, and February 28, 1911—the Tucker Brook critical period—was 22.00 inches. This compares very closely to the rainfall on the Housatonic River drainage area between July 1, 1940, and February 28, 1941, which amounted to 22.01 inches, and this period did not compute to be a critical one on the Housatonic River. It seems obvious, therefore, that the available records of flow of the Housatonic River cover periods as critical as the 1908-1911 period.

There are no yield or rainfall data available for the 1908-11 period in the vicinity of the Quaboag River, but it should be noted that the Storage-Yield relations lie about midway between the data for the Sudbury and for the Wachusett watersheds and these do include the 1908-11 period. It seems reasonable to assume, therefore, that the available data produce Storage-Yield relations which would be little changed by 1908-11 data, if such were available.

Further studies will be made on additional watersheds and, when periods of drought change the data previously published, the proper changes will be made. For this reason, your committee respectfully suggests that it be continued and allowed to report from time to time.

For the Committee,

(*Signed*) ARTHUR D. WESTON, *Chairman*

PRELIMINARY REPORT OF COMMITTEE ON WATER DISTRIBUTION SAFETY

September, 1948

To the New England Water Works Association:

During April, 1946, the Executive Committee appointed the undersigned three members of the New England Water Works Association to serve as a joint committee with the American Water Works Association on Water Distribution Safety. A similar committee of the A.W.W.A. had been in existence for a number of years and had prepared a "Tentative Manual of Safe Practice in Water Distribution", published in June, 1942 (*Jour. A.W.W.A.*, Vol. 34, pp. 917-936, June, 1942).

During the past year the United States Public Health Service published Public Health Bulletin No. 296, entitled "Manual of Recommended Water-Sanitation Practice", which was written by a technical committee of Public Health Service officers, primarily, "to serve as a guide to Public Health Service engineers in evaluating the sanitary features of water supplies with which they are concerned." Bulletin No. 296 is dated 1946, but has been available in published form only since late 1947.

This U.S.P.H. Bulletin has been under discussion for some time. Your committee has made certain efforts to influence the U.S.P.H.S. in the wording of Bulletin No. 296. Your committee has also circulated the A.W.W.A. Tentative Manual among water-works men. A number of comments have been received and others are awaited.

Bulletin No. 296 is the second effort by the United States Public Health Service to set up a "Manual of Recommended Water-Sanitation Practice". The first manual, published in January, 1943, as Reprint No. 2440 from the Public Health Reports, was issued in conjunction with the 1942 revision of the Water Quality Standards. This combination of water standards with the manual on water-sanitation practice resulted in many objections from the water-works industry. The 1946 Water Quality Standards were issued alone and have been officially adopted by certain water-works associations.

Public Health Bulletin No. 296 covers more than the water dis-

tribution system. The scope of this committee on Water Distribution Safety is covered by Bulletin No. 296 in the following sections:

Part I—*Physical Features of Water-Supply Systems and Their Protection*
- E. Distribution System (Exclusive of Reservoirs or Standpipes), pp. 8, 9 and 1/3 of 10
- F. Storage (Reservoirs on Distribution System), pp. 10 and 11

Part III—*Recommended General Sanitary Requirements for Water Distribution Systems*
- A. General, pp. 25-26
- B. Piping System, pp. 26-27
- C. Storage, pp. 27-28
- D. Interconnections, cross and open connections, p. 29

Thus, Public Health Bulletin No. 296 covers the scope of your reporting committee in about 7½ printed pages (6 in. by 9 in.). It is probable that the operating water-works man may find certain of the recommendations objectionable. Extended study might suggest modifications or additions.

However, your committee proposes that any *Manual of Safe Practice in Water Distribution* for the guidance of the water-works industry should be developed by water-works men. This is in line with the procedure of many years' standing, wherein the water-works industry has produced a considerable number of standard specifications and manuals of practice.

To implement this general principle, the "Tentative Manual of Safe Practice in Water Distribution", published in 1942 by the A.W.W.A., may be taken as an initial draft and modifications made on the basis of study and comments by practical, operating water-works men.

Your committee requests that men interested in producing a manual of practice representing the ideas of the water-works industry review both Public Health Bulletin No. 296 and the "Tentative Manual of Safe Practice in Water Distribution", published by A.W.W.A. in June, 1942, and then send suggestions to the Committee on Water Distribution Safety.

Respectfully submitted,

(*Signed*) WILLIAM E. STANLEY, *Chairman*
DONALD C. CALDERWOOD
FRANK A. MARSTON

PROGRESS REPORT OF COMMITTEE ON SPECIFICATIONS FOR CAST-IRON PIPE AND FITTINGS

September 9, 1948

To the New England Water Works Association:

During the past year, the work of the Committee A-21 of the American Standards Association, the membership of which includes the undersigned as your representatives, has been largely devoted to matter of detail in the various specifications under consideration.

Progress has been made on specifications for pipe cast centrifugally in metal molds and in sand-lined molds, much attention having been given to the manner in which test bar, strip, ring and bursting tests shall be applied to these two types of pipe. Agreement having been reached in the subcommittee, these specifications are now being edited for submission to the Committee.

Details of short-body fittings in the smaller sizes are practically in final form, but progress on the larger fittings has been slow, because the shops have been preoccupied with production and have little or no time for research. Consideration is being given to the standardization of mechanical joints, increase in use of which has emphasized the need for uniformity.

Work on pipe coatings has been continued. Changes in details of cement-lining specifications have been studied, in view of changing technique, and it is probable that a modified form will be offered soon to the Committee by the subcommittee dealing with this subject. Further consideration of specifications for tar coating has been abandoned because of insurmountable difficulties.

It is believed to be advantageous that the New England Water Works Association continue its representation on ASA Committee A-21.

Respectfully submitted,

(*Signed*) ARTHUR L. SHAW
ELSON T. KILLAM

REPORT OF COMMITTEE ON REINFORCED CONCRETE PRESSURE PIPE

To the New England Water Works Association:

During the past two years, your committee has acted jointly with the Water Works Practice Committee 7-B of the American Water Works Association in the preparation of the Tentative Standard Specifications for Reinforced Concrete Water Pipe—Steel Cylinder Type, Not Prestressed.

Preliminary drafts of these specifications have been received and suggestions by your committee forwarded to the Chairman, Ernest W. Whitlock, most of which suggestions were incorporated in the tentative specifications adopted and printed in the March, 1948, Journal of the American Water Works Association and in the June, 1948, Journal of the New England Water Works Association.

Proposals have been made that this joint Committee now prepare specifications for prestressed, reinforced-concrete water pipe, with and without steel cylinders, as well as reinforced-concrete water pipe not prestressed and without a steel cylinder, for low-head design. As yet, as far as we know, no authorization has been given to this Committee to prepare such specifications, although proposed federal specifications have already been drafted for pipe, concrete, pressure, prestressed reinforced and with steel cylinder.

It is advisable to continue your committee for such work as later develops on the above tentative specifications or on the preparation of specifications proposed for the other types of concrete pipe, if such preparation by the Water Works Practice Committee of the A.W.W.A. is directed.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
GEORGE A. SAMPSON

REPORT OF HYDRANT SPECIFICATION COMMITTEE

To the Members of the New England Water Works Association:

Your Hydrant Specification Committee wishes to report progress.

The Committee sat in with the American Water Works Association Committee on Hydrant Specifications at the Atlantic City Convention and discussed the specifications in general.

We agree that, with a few revisions in the present specifications, we would all mutually benefit from such changes.

We are in hopes that a final report can be presented during the coming year and, therefore, we suggest that the present Committee be continued for another year.

Respectfully submitted,

(*Signed*) ROGER W. ESTY, *Chairman*
HAROLD W. GRISWOLD
HARRY U. FULLER

PROGRESS REPORT OF COMMITTEE ON GATE VALVE SPECIFICATIONS

September 10, 1948

To the New England Water Works Association:

Your Committee on Gate Valve Specifications submits the following progress report.

At the request of F. M. Randlett, Chairman of the A.W.W.A. Committee on Valve Specifications, your Committee prepared and submitted, in March of this year, a revised draft of the specifications, which followed the form and arrangement approved by the Joint Committee at the 1947 A.W.W.A. Convention at San Francisco. It was hoped that this draft, together with others submitted by various members of the Joint Committee, would form the basis for a new valve specification for consideration at the 1948 A.W.W.A. Convention at Atlantic City. This hope was not realized and, while a committee meeting was held at Atlantic City, only three people attended and no business was transacted.

Since the A.W.W.A. Committee on Valve Specifications has neither completed its work nor been disbanded, it is suggested that your Committee on Gate Valve Specifications be continued for another year.

Respectfully submitted,

(*Signed*) HAROLD W. GRISWOLD, *Chairman*
LELAND G. CARLTON
WALTON H. SEARS

REPORT OF COMMITTEE ON LAYING CAST-IRON PIPE

September 7, 1948

To the Members of the New England Water Works Association:

Your Committee on Laying Cast-Iron Pipe was appointed to coöperate with a corresponding committee of the A.W.W.A. in revising its "Standard Specifications for Laying Cast-Iron Pipe" (7D.1-1938).

The 1938 Specifications included not only excavating and backfilling for, and laying and jointing of, pipe, but also chlorination of completed pipe lines. However, during preparation of the first draft of the revision, it was decided to remove from the Specifications for Laying Cast-Iron Pipe all details relating to sterilization and to develop separately "A Procedure for Disinfecting Water Mains." A subcommittee of the A.W.W.A., under the chairmanship of the late Cecil K. Calvert, developed such a procedure. This has been adopted as tentative and awaits final action by the A.W.W.A. Committee on Water Works Practice and Board of Directors not earlier than January, 1949. This "Procedure", with accompanying discussion by Mr. Calvert, was published in the February, 1948, Journal of the A.W.W.A.

The second draft of the revised specifications for laying pipe is now under consideration. In due course this specification will be finally revised and presented for action by the A.W.W.A. officials.

Following final action by the A.W.W.A., your committee will submit both "Procedure" and "Specifications" for your consideration.

Respectfully submitted,

(*Signed*) W. S. MARINER, *Chairman*
GEORGE W. COFFIN

PROGRESS REPORT OF COMMITTEE ON SPECIFICATIONS FOR STEEL PIPE

To the New England Water Works Association:

Presented herewith is a progress report for the Committee on Specifications for Steel Pipe.

There has been no active work during the past year upon standard specifications by the members of your committee as a committee, but studies have been made by them, as individuals, of revisions of existing and proposed specifications in connection with specific projects.

For example, the high cost of labor for riveted, field, girth joints led to specifying in some instances the use of couplings such as the Dresser coupling for field joints. Welded field joints for girth joints, with or without occasional expansion joints, have been used, but the Committee feels that a joint capable of taking expanding forces every 30 or 40 feet should be used.

Longitudinal joints are today generally permitted to be welded, as are the shop girth joints.

The high cost of steel plate and the difficulty in obtaining quick delivery of it have made it imperative to design with the lowest factors of safety, consistent with good design, and to specify the best coatings and linings.

The time required for its delivery and the rising costs of steel require that the conditions affecting its use be carefully considered, to be assured that time for delivery and appropriations are available for each construction project.

Respectfully submitted,

(*Signed*) STANLEY M. DORE
SCOTT KEITH

REPORT OF COMMITTEE ON THREADS FOR UNDERGROUND SERVICE LINES

August 11, 1948

To the Executive Committee,
New England Water Works Association

GENTLEMEN:

Under date of October 16, 1947, your committee approved the specifications for threads for underground service lines on a tentative basis. Similar action had previously been taken by the American Water Works Association.

During the past spring, our committee requested the manufacturers who had been active in the consideration of these threads and also the members of the committees on this subject in the American Water Works Association and in the New England Water Works Association to advise if it had been found desirable to recommend any changes in these tentative specifications and the drawings which accompanied such specifications.

As no changes have been suggested, Committee 7-T of the American Water Works Association recommended that the specifications be advanced from the tentative to the accepted standards status. This recommendation was approved by the Water Works Practice Committee of the American Water Works Association. Said approval is now being acted upon by the Board of Directors of the American Water Works Association through a letter ballot. There appears to be no reason to doubt that the board will accept the specifications as standards.

Under the foregoing conditions, our committee recommends that the New England Water Works Association accept the specifications and their accompanying drawings as standards and, upon such acceptance, that our committee be discharged.

Respectfully,

(*Signed*) WM. W. BRUSH, *Chairman*
D. C. CALDERWOOD

Committees of the New England Water Works Association
1948 - 1949

N.E.W.W.A.—1. Committee on Technical Program: Truman H. Safford, *Chairman,* George G. Bogren, William B. Duffy, George C. Houser, Paul F. Howard, Jack E. McKee, Thomas E. Kennedy and Marshall S. Wellington.

N.E.W.W.A.—2. Committee on Northern New England Meeting: Peter C. Karalekas.

N.E.W.W.A.—3. Committee on Southern New England Meeting: Philip J. Holton, Jr.

N.E.W.W.A.—4. Committee on Finance: Kenneth W. Robie, *Chairman,* John B. Kennedy and Howard C. Mandell.

N.E.W.W.A.—5. Committee on Membership: John B. Kennedy, *Chairman,* Theodore Cate, Elmer W. Campbell, Harold W. Griswold, Joseph E. Moore and Walter J. Shea.

N.E.W.W.A.—6. Committee on Library: Karl R. Kennison and Harry L. Kinsel.

N.E.W.W.A.—7. Committee on Committees: Warren J. Scott, *Chairman,* Roger W. Esty, Harry U. Fuller, Earl R. Perry and William E. Stanley.

N.E.W.W.A.—8. Committee on Legislation: Mark F. Croker, *Chairman,* Theodore L. Bristol, Walter C. Conroy, Philip J. Holton, Jr., G. Arthur Faneuf, Harry U. Fuller and Edward L. Tracy.

N.E.W.W.A.—9. Committee on Reciprocal Relations with the Institution of Water Engineers (England): E. Sherman Chase, *Chairman,* Leland G. Carlton and Percy A. Shaw.

N.E.W.W.A.—10. Committee on Classification of Water Works Employees and Salaries: Walter C. Conroy, *Chairman,* Sydney C. Beane, Albert E. Casey, Roger G. Oakman and Allen M. Symonds.

N.E.W.W.A.—11. Committee on Survey of Ground Water Supplies in New England: Leslie K. Sherman, *Chairman,* M. L. Brashears, Jr., William A. Healy, Vincent M. Hynes, Howard H. Potter, Walter J. Shea and Edward L. Tracy.

N.E.W.W.A.—12. Committee on Rainfall and Yield of Drainage Areas: Francis H. Kingsbury, *Chairman,* Harold K. Barrows, Allan T. Gifford, Peter C. Karalekas, Harvey B. Kinnison, Arthur T. Safford, Caleb M. Saville, Ralph M. Soule, Miner R. Stackpole, Howard M. Turner and William A. D. Wurts.

N.E.W.W.A.—13. Committee on Distribution System Safety (Joint with American Water Works Association): William E. Stanley, *Chairman,* Donald C. Calderwood and Frank A. Marston.

N.E.W.W.A.—15. Committee on Cathodic Protection of Steel Tanks and Standpipes: Howard E. Bailey, *Chairman*, Sidney S. Anthony, Donald C. Calderwood, Richard H. Ellis, Harry U. Fuller, William P. Melley and Samuel G. Wylie.

N.E.W.W.A.—16. Committee on Coefficients for Friction in Pipe Lines: Elson T. Killam, *Chairman*, William W. Brush, E. Shaw Cole and F. William Haley.

N.E.W.W.A.—17. Committee to Investigate Grounding (Cooperating with American Research Committee on Grounding): George A. Sampson, *Chairman*, Warren A. Gentner, Arthur V. Harrington and Edward E. Minor.

N.E.W.W.A.—18. Committee to Report on Developments in Water Quality Standards: Arthur D. Weston, *Chairman*, Almon L. Fales and Edward W. Moore.

N.E.W.W.A.—19. Committee on Water Quality Tolerances for Industrial Uses: Edward W. Moore, *Chairman*, Stuart E. Coburn, Louis A. Olney, George A. Sampson and Hervey J. Skinner.

N.E.W.W.A.—20. Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation: Edward W. Moore, *Chairman*, Lazarus Rubin and Walton H. Sears.

N.E.W.W.A.—21. Committee on Specifications for Cast-Iron Pipe and Fittings (Sectional Committee under American Standards Association): Elson T. Killam and Arthur L. Shaw.

N.E.W.W.A.—22. Committee on Reinforced Concrete Pressure Pipe (Joint with American Water Works Association): Stanley M. Dore, *Chairman*, and George A. Sampson.

N.E.W.W.A.—23. Committee on Code for Pressure Piping (Joint with American Society of Mechanical Engineers): Thomas F. Wolfe.

N.E.W.W.A.—24. Committee on Laying Cast-Iron Pipe (Joint with American Water Works Association): W. S. Mariner, *Chairman*, and George W. Coffin.

N.E.W.W.A.—25. Committee on Specifications for Steel Pipe (Joint with American Water Works Association): Stanley M. Dore and Scott Keith.

N.E.W.W.A.—26. Committee on Standardization of Pipe Flanges and Fittings (Sectional Committee under American Standards Association): Elson T. Killam.

N.E.W.W.A.—28. Committee on Steel Standpipes and Elevated Tanks (Joint with American Water Works Association): George A. Sampson, *Chairman*, Howard E. Bailey, Harry U. Fuller and Henry E. Halpin.

N.E.W.W.A.—29. Committee on Valve Box Frames and Covers (Joint with American Water Works Association): Sidney S. Anthony, *Chairman*, and Scott Keith.

N.E.W.W.A.—30. Committee on Meter Specifications (Joint with American Water Works Association): Richard H. Ellis, *Chairman*, Warren A. Gentner and Dwight H. Hall.

N.E.W.W.A.—31. Committee on Hydrant Specifications (Joint with American Water Works Association): Roger W. Esty, *Chairman*, Harry U. Fuller and Harold W. Griswold.

N.E.W.W.A.—32. Committee on Gate Valves (Joint with American Water Works Association): Harold W. Griswold, *Chairman*, Leland G. Carlton and Walton H. Sears.

N.E.W.W.A.—33. Committee on Sluice Gates (Coöperating with American Water Works Association): Elson T. Killam, *Chairman*, and Harold W. Griswold.

N.E.W.W.A.—37. Committee on Federal Activities (Joint with American Water Works Association): Fred S. Gibbs.

BOOK REVIEW

The Quest for Pure Water. By M. N. Baker. xiv+527 pp. New York, N. Y.: The American Water Works Association, Inc., 1948. $5.00.

This book, as indicated by its sub-title, sets forth "the History of Water Purification from the Earliest Records to the Twentieth Century". The first three chapters are devoted to the records of the years from 2,000 B.C. to the early nineteenth century A.D. In the next eight chapters the author tells the story of the development of filtration in Europe and America, including slow sand filtration, rapid filtration, upward filtration, multiple filtration, drifting-sand rapid filters and natural filters (basins and galleries). The last half of the book deals with other methods of purification—namely, plain sedimentation, coagulation, disinfection, distillation, aeration, softening, color removal, iron and manganese removal, and taste and odor control (including algae troubles and their conquest)—together with medication by means of the water supply.

The history of water purification is unfolded in an entertaining manner, even though the volume is replete with references to the source material which had been consulted by the author. As a matter of fact, the bibliography includes nearly 900 entries relating to books, pamphlets, papers read before professional societies, and personal letters from authorities in America and abroad. The value of the book is enhanced by the inclusion of 73 illustrations, together with a 17-page index of all men and localities mentioned in the text and footnotes.

That New England has played an important part in the development of water purification is attested by the fact that the following New England cities, towns and villages are mentioned in the book, either briefly or at considerable length: Greenwich, Hartford, New Britain, New Haven, New Milford, Norwich and South Norwalk, Conn.; Augusta, Brunswick and Lewiston, Me.; Athol, Boston, Brockton, Brookline, Easton, Great Barrington, Holyoke, Lawrence,

Lowell, Lynn, Marlborough, Middleborough, Nantucket, Newton, Reading, Shirley, Springfield, Stockbridge, Taunton, Waltham, Wellesley, Whitinsville and Worcester, Mass.; Exeter, Keene and Manchester, N. H.; Newport, Pawtucket and Providence, R. I., and Rutland and St. Johnsbury, Vt.

The author's viewpoint is well illustrated by the following quotation from the "Epilogue":

"Although the purification of city water supplies was not undertaken until the latter part of the eighteenth century, and by then only haltingly, the earlier and isolated methods of treatment used during the previous three thousand years have also been reviewed. They illustrate man's never-ending quest for pure water. They foreshadow things to come, and they show what might have come much earlier if the demand for pure water had kept pace with increasing knowledge of means for its acquisition."

GEORGE C. HOUSER

A.W.W.A. 7H.1—1948
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STANDARD SPECIFICATIONS
for
ELEVATED STEEL WATER TANKS, STANDPIPES AND RESERVOIRS

American Water Works Association
American Welding Society
New England Water Works Association

These "Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs" are based upon the best known experience and are intended for use under normal conditions. They are not designed for unqualified use under all conditions and the advisability of use of the material herein specified for any installation must be subjected to review by the engineer responsible for the construction in the particular locality concerned.

Approved as Revised, by the Board of Directors of the A.W.W.A., September 20, 1948; by the Board of Directors of the American Welding Society, October 25, 1948; and by the New England Water Works Association, September 14, 1948.

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AMERICAN WATER WORKS ASSOCIATION
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500 Fifth Avenue, New York 18, N.Y.

Foreword

These specifications were prepared by a joint committee of the American Water Works Association and the American Welding Society consisting of L. R. Howson, General Chairman, H. O. Hill, H. A. Sweet, Bryan Blackburn, J. P. Schwada, J. O. Jackson, H. C. Boardman and N. T. Veatch Jr.

These specifications are a revision and extension to include welded construction of the specifications entitled "Standard Specifications for Riveted Steel Elevated Tanks and Standpipes" which were prepared by Subcommittee 7H of the American Water Works Association and published tentatively in the JOURNAL in December, 1931, and finally in the JOURNAL, November, 1935. Those specifications covered riveted construction only. The purpose of the present specifications is to provide a uniform guide for minimum requirements as to the design, fabrication and erection of elevated steel water tank, standpipe and reservoir structures of either welded or riveted construction.

All requirements relative to welding in these specifications have been taken from American Welding Society "Rules for Field Welding of Steel Storage Tanks."

These specifications were approved as "Tentative Standard" by the Executive Committee of the American Welding Society on April 4, 1940; and by the Board of Directors of the American Water Works Association on April 25, 1940. These specifications were approved as "Standard" by the Board of Directors of the American Water Works Association on June 26, 1941; by the Executive Committee of the American Welding Society on July 23, 1941; and by the New England Water Works Association on September 24, 1942. The latest revisions of these specifications were approved by the Board of Directors of the American Water Works Association on September 20, 1948; by the Board of Directors of the American Welding Society on October 25, 1948; and by the New England Water Works Association on September 14, 1948.

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NOTE: Several of the references to A.S.T.M. Specifications in Section 2 were changed, effective July 1947, to accord with new A.S.T.M. designations.

STANDARD SPECIFICATIONS FOR ELEVATED STEEL WATER TANKS, STANDPIPES AND RESERVOIRS

Section 1—General

1.1. *Local Requirements:* Where local, municipal, county, state or government requirements exist such requirements are to govern and these specifications shall be interpreted to supplement them.

1.2. *Definitions:* Under these specifications the following definitions will apply:

Elevated Tank shall mean a container or storage tank supported on a tower.

Standpipe shall mean a flat bottom cylindrical tank having a shell height greater than its diameter.

Reservoir shall mean a flat bottom cylindrical tank having a shell height equal to or smaller than the tank diameter.

Tank shall mean an elevated tank, a standpipe or a reservoir.

Purchaser shall mean the person, company or organization which purchases the tank.

Engineer shall refer to the purchaser's engineer.

Contractor shall mean the person or company who contracts with the purchaser under these specifications to furnish and erect the tank.

Capacity shall mean that contained between the level of the overflow and the lowest specified level.

1.3. *What the Purchaser Is to Furnish:* The purchaser shall furnish the site upon which the tank is to be built with sufficient space to permit the contractor to erect the structure using customary methods. The purchaser shall furnish foundations. Unless otherwise agreed the purchaser shall furnish at the tank site the water at the proper pressure for testing and facilities for disposing of waste water, after testing. The purchaser shall furnish a suitable right of way from the nearest public road to the erection site.

1.4. *What the Contractor Is to Furnish:* The contractor shall furnish foundation plans, the anchor bolts, all materials except for foundations, all labor necessary to complete the structure including the accessories required by these specifications and any additional work or accessories separately specified by the purchaser.

1.5. *Information to Be Furnished by Purchaser:* In his advertisement or inquiry the purchaser shall furnish the information itemized in Sec. A2 for elevated tanks or that in Sec. A3 for standpipes or reservoirs.

1.6. *Information to Be Furnished by Bidder:* Each bidder shall furnish the information itemized in Sec. A4 for elevated tanks or that in Sec. A5 for standpipes or reservoirs.

1.7. *Guarantee:* The contractor shall guarantee the structure against

any defective materials or workmanship including paint and painting if in accordance with Sec. A8, A9, and A10 for a period of one year from date of completion. If any materials or workmanship prove to be defective within one year they shall be replaced or repaired by the contractor.

Section 2—Materials

2.1. *Bolts, Anchor Bolts and Threaded Rods:* Bolts, anchor bolts and threaded rods shall conform to any of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings (Bolting Materials); A 141, Specifications for Structural Rivet Steel; A 31, Specifications for Boiler Rivet Steel and Rivets; or A 107, Hot-Rolled Carbon Steel Bars, Grades 1008, 1010 and 1015.

2.2. *Reinforcing Steel:* Reinforcing steel shall comply with the latest revision of A.S.T.M. Specifications A 15 (structural or intermediate grade).

2.3. *Plates:* Plate materials shall be open-hearth steel conforming to any of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings; A 283, Grades A, B, C and D—Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality; A 285, Grades A, B and C—Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Flange and Fire-Box Qualities; or A 113, Specifications for Structural Steel for Locomotives and Cars (plates for cold pressing).

2.4. *Basis of Furnishing Plates:* Plates in the tank shell and suspended bottom shall not underrun the required thickness, based upon the specified unit stress, by more than 0.01 in. All other plates may be furnished on the weight basis with permissible underrun and overrun according to the tolerance table for plates ordered to weight published in the applicable A.S.T.M. specification.

2.5. *Structural Shapes:* Structural materials shall be open-hearth steel conforming to either of the following A.S.T.M. specifications of the latest revision: A 7, Specifications for Steel for Bridges and Buildings; or A 113, Specifications for Structural Steel for Locomotives and Cars (structural steel for locomotives).

2.6. *Copper Bearing Steel:* Copper bearing steel with content of about 0.20 per cent copper may be used when specified. In other particulars the steel shall conform to specifications enumerated above.

2.7. *Rivets:* Rivets shall comply with the latest revision of A.S.T.M. Specifications A 31 or A 141. If cold driving is done, properly annealed rivets conforming to A.S.T.M. Specifications A 31 should be used.

2.8. *Pins:* Pins shall comply with A.S.T.M. specifications A 7 (Bolting Material) or A 108 Grade 1025 of the latest revision.

2.9. *Castings:* Castings shall conform to the latest revision of A.S.T.M. specification A 27, Grade 60–30, Specifications for Medium-Strength Steel Castings for General Application.

2.10. *Forgings:* Forgings shall conform to one of the following A.S.T.M. specifications of the latest revision:

2.10.1. *Plate Forgings:* A 283, Grades A, B, C and D—Specifications for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (plates 2 in. and under in thickness); A 285, Grades A, B and C—Specifications for Low and Intermediate Tensile Strength Carbon Steel Plates of Flange and Fire-box Qualities (plates 2 in. and under in thickness).

2.10.2. *Forgings, Other than Plate:* A 235, Class B, Specifications for Carbon-Steel Forgings for General Industrial Use.

2.10.3. *Forged and Rolled Pipe Flanges:* A 181, Grade I, Specifications for Forged or Rolled Steel Pipe Flanges for General Service.

2.11. *Filler Metal:* The specifications cited below shall be followed for filler metal:

2.11.1. *Electrodes:* All arc-welding electrodes shall conform to the requirements of the A.W.S.—A.S.T.M. Specifications for Iron and Steel Arc-Welding Electrodes (A.W.S. designation A 5.1; A.S.T.M. designation A 233) of the latest revision. Electrodes shall be of classifications E 6010, E 6011, E 6012, E 6013, E 6020 and E 6030, and shall be suitable for the positions of welding and other conditions of intended use.

2.11.2. *Gas-Welding Rods:* All gas-welding rods shall conform to the requirements of the A.W.S.—A.S.T.M. Specifications for Iron and Steel Gas-Welding Rods (A.W.S. designation A 5.2, A.S.T.M. designation A 251) of the latest revision. Welding rods shall be of classification GA-60 and shall be suitable for the conditions of intended use.

Section 3—General Design

3.1. *Type of Joints:* Unless specifically restricted by the purchaser, joints and connections in structures built under these specifications may be either riveted or welded or parts may be riveted or welded at the option of the contractor.

Lap welded joints between plates in contact with tank contents except bottom plates supported directly on grade or foundation shall be welded continuously on both edges.

3.2. *Design Loads:* The following loads shall be considered in the design of tank structures:

3.2.1. *Dead load* shall be the estimated weight of all permanent construction and fittings. The unit weight of steel shall be considered 490 lb. per cu.ft. and of concrete 144 lb. per cu.ft.

3.2.2. *Live load* shall be the weight of all of the liquid when the tank is filled to overflowing. Unit weight of water shall be considered as 62.4 lb. per cu.ft. The weight of any water, supported directly on foundations, shall not be considered as a live load on the superstructure.

3.2.3. *Snow load* shall be 25 lb. per sq.ft. of the horizontal projection of the tank for surfaces having a slope of less than 30 deg. with the horizontal. For greater roof slope snow loads shall be neglected.

3.2.4. *Wind load* or pressure shall be assumed to be 30 lb. on vertical plane surfaces, 18 lb. on projected areas of cylindrical surfaces and 15 lb. per sq.ft. on projected areas of conical and double curved plate surfaces. (It may be desirable to increase the wind loads above by as much as 50 per cent in hurricane areas.)

For columns and struts of structural shapes, the projected area shall be calculated. Struts on the leeward side of the tower shall be assumed as being shielded 50 per cent by those on the windward side. In the case of columns and sway rods, the wind pressure shall be applied on the projected area of each member.

In calculating the wind load on elevated tank structures the entire wind load on the tank, roof and bottom and the proper proportion of the wind load from the riser pipe and tower shall be assumed to act on the tank at the center of gravity of such loads.

3.2.5. *Earthquake Load:* If any provision is to be made in the design for earthquake resistance the purchaser shall so specify. *Note:* Present practice is to assume a horizontal force of from 5 to 20 per cent of the total weight of the water in the tank and riser acting at the center of mass of the water, the percentage used depending upon the proximity of an earthquake-producing fault and the hazard to surrounding property in the event of an earthquake failure or upon local regulations.

3.2.6. *Balcony and Ladder Load:* A vertical load of 1000 lb. shall be assumed to be applied to any point on the balcony floor, if any, and on each platform; 500 lb. at any point on the tank roof; 350 lb. on each section of ladder; and all of the structural parts and connections shall be properly proportioned to withstand such loads.

3.3. *Unit Stresses:* With the exceptions specifically provided for elsewhere in these specifications, all steel members shall be so designed and proportioned that, during the application of any of the loads previously specified, or any combination of them, the maximum stress shall not exceed the following:

	Maximum Fiber Stress psi.
3.3.1. *Tension:*	
Structural steel	15,000
Rivets, on area based on nominal diameter	11,250
Bolts, on area based on diameter at root of threads	11,250
Cast steel	11,250
Steel Plates in tank shells (see exceptions in Sec. 5.10).	15,000
3.3.2. *Compression:*	
Structural steel and weld metal	15,000
Columns and struts	*See* Sec. 3.5
Plate girder stiffeners	15,000
Webs of rolled sections at toe of fillet	18,000
Cast steel	15,000
3.3.3. *Bending:*	
Tension on extreme fibers, except column base plates	15,000
Column base plates	20,000
Compression on extreme fibers of rolled sections, and built-up girders and built-up members, for values of $\frac{l}{b}$ not greater than 40, where l is laterally unsupported length of the member and b is the width of the compression flange	$\frac{16,875}{1 + \frac{l^2}{1,800b^2}}$ with a maximum of 15,000
Pins, extreme fiber	22,500
Cast steel	11,250
3.3.4. *Shearing:*	
Rivets	11,250
Pins and turned bolts in reamed or drilled holes	11,250
Unfinished bolts	7,500
Webs of beams and plate girders, gross section	9,750
Cast steel	7,325

3.3.5. *Bearing:*

	Double Shear	*Single Shear*
Rivets	30,000	24,000
Turned bolts in reamed or drilled holes	30,000	24,000
Unfinished bolts	18,750	15,000
Pins	24,000	
Contact area of milled surfaces	22,500	
Contact area of fitted stiffeners	20,250	
Expansion rollers and rockers (pounds per linear inch) where d is the diameter of roller or rocker in inches		$600d$
Concrete (see Sec. A22)		
2,000 lb. Concrete		500
2,500 lb. Concrete		625
3,000 lb. Concrete		750

Unit stress values wherever stated in these specifications shall be reduced by multiplying them by the applicable joint efficiencies.

3.4. *Combined Stresses:*

3.4.1. *Axial and Bending:* Members subjected to both axial and bending stresses shall be so proportioned that the quantity $\frac{fa}{Fa} + \frac{fb}{Fb}$ shall not exceed unity, in which:

Fa is the axial unit stress that would be permitted by this specification if axial stress only existed.

Fb is the bending unit stress that would be permitted by this specification if bending stress only existed.

fa is the axial unit stress (actual) = axial stress divided by area of member.

fb is the bending unit stress (actual) = bending moment divided by section modulus of member.

3.4.2. *Rivets:* Rivets subject to shearing and tensile forces shall be so proportioned that the combined unit stress will not exceed the allowable unit stress for rivets in tension only.

3.4.3. *Wind and Other Forces:* Members including foundations subject to stresses produced by a combination of wind and/or earthquake and other loads may be proportioned for unit stresses 25 per cent greater than those specified in Sec. 3.3 and 3.5, provided the section thus required is not less than that required for the combination of dead load and live load. It is not necessary to combine wind stress and earthquake stress, but to proportion each member for the larger of the two in combination with stresses produced by other causes.

Members subject only to stresses produced by wind forces and/or earthquake forces may be proportioned for unit stresses 25 per cent greater than those specified in Sec. 3.3 and 3.5.

3.5. *Column and Strut Formulas:* The following formulas shall be applied:

3.5.1. *Structural Sections:* The maximum permissible unit stress for structural columns or struts shall be determined from the following formula:

$$\frac{P}{A} = \left[\frac{18000}{1 + \frac{L^2}{18000r^2}}\right]$$

or 15,000 psi., whichever is smaller.

3.5.2. *Tubular Sections:* The maximum permissible stress for tubular columns and struts shall be determined by the formula:

$$\frac{P}{A} = XY,$$

in which:

$$X = \frac{18000}{1 + \frac{L^2}{18000r^2}}$$

or 15,000 psi., whichever is the smaller, and

$$Y = \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\left[2 - \left(\frac{2}{3}\right)\left(100\,\frac{t}{R}\right)\right]$$

or unity (1.00), whichever is the smaller.

In the foregoing formulas, the symbols have the following meaning:

P = the total axial load in pounds.
A = the cross-sectional area in square inches.
L = the effective length in inches.
r = the least radius of gyration in inches.
R = the radius of the tubular member to the exterior surface in inches.
t = the thickness of the tubular member in inches; minimum allowable thickness $\frac{1}{4}$ in.

All circumferential joints in tubular sections shall be butt joints either welded for complete penetration or riveted with butt straps on both sides.

3.6. *Slenderness Ratio:* The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying weight or pressure of tank contents shall be 120.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for compression members carrying loads from wind and/or earthquake only shall be 175.

The maximum permissible slenderness ratio $\left(\frac{L}{r}\right)$ for columns carrying roof loads only shall be 175.

3.7. *Roofs and Top Girders:* All tanks storing drinking water should have roofs. Tanks without roofs shall have a top girder or angle having a minimum section modulus as determined by the following formula:

$$S = \frac{HD^2}{10000}$$

In the above formula S is the minimum required section modulus in inches cubed of the top angle or girder, including a length of tank shell equal to twenty times its thickness; H is the height of the cylindrical portion of the tank shell in feet; and D is the diameter of the cylindrical portion of the tank shell in feet.

3.8. *Roof Supports:* Roof supports, if any, shall be designed in accordance with the current specifications of the American Institute of Steel Construction, except that the ratio $\frac{l}{b}$ of unbraced length to width of flange of rafters in contact with roof sheets shall not be restricted, as it is considered that the roof sheets will provide lateral supports for the rafters, and except that the maximum slenderness ratio $\frac{L}{r}$ for columns supporting roofs shall be 175.

Roof trusses shall be placed above the maximum water level in climates where ice may form.

Roof rafters shall preferably be placed above the maximum water level but it will be permissible for their lower ends, where they connect to the tank shell, to project below the water level.

3.9. *Foundation Bolts:* Foundation bolts may be either plain or deformed bars, either upset or not upset. They shall be proportioned for the maximum possible uplift, using the area at the base of the thread or the un-upset rod diameter, whichever is smaller. Foundation bolts may extend into the pier to within 3 in. from the bottom of the pier, but not necessarily more than far enough to develop the maximum uplift, and shall terminate in a right angle bend, hook or washer plate. The threaded ends of foundation bolts shall extend 2 in. above the nominal level of the tops of the foundation bolt nuts to provide for variations in the foundations. Lock nuts shall be provided or the threaded ends of anchor bolts shall be peened to prevent loosening of anchor nuts.

3.10. *Corrosion Allowance:* Careful consideration shall be given by the purchaser to the proper allowance for corrosion. This allowance will depend upon the corrosive nature of the stored water, the proximity of the tank to salt water or other causes of atmospheric corrosion and the care with which the paint or other protection will be maintained. If corrosion allowance is desired the purchaser shall specify the allowance for parts in contact with water and for parts not in contact with water. The corrosion allowance specified by the purchaser is to be added to the thickness determined from the specified design units and to the minimum thicknesses specified in the following section. In the case of beams and channels, the corrosion allowance need be added to the webs only and not to the flanges.

3.11. *Minimum Thickness:* The minimum thickness for any part of the structure shall be $\frac{3}{16}$ in. for parts not in contact and $\frac{1}{4}$ in. for parts in contact with water contents. The minimum thickness for tubular columns and struts shall be $\frac{1}{4}$ in. Round or square bars used for wind bracing shall have a minimum diameter or width of $\frac{5}{8}$ in. Bars of other shapes, if used, shall have a total area at least equal to a $\frac{5}{8}$ in. round bar.

3.12. *Joints in Shell Plates:* In calculating the thicknesses of plates stressed by the weight or pressure of the tank contents, the pressure at the lower edge of each ring shall be assumed to act undiminished on the entire area of the ring. Joints subjected to stress from weight or pressure of tank contents in adjacent courses shall be staggered.

3.13. *Riveted Joint Design:* The riveted joint design shall comply with current good practice as regards the size of rivets, edge distance for calking and non-calking edges, the angle of bevel of calking edges and the minimum and maximum rivet pitches and back pitches.

The following represents good practice:

The minimum rivet pitch shall be not less than three times the nominal diameter of the rivet.

The maximum pitch along a calked edge where the calking is necessary for water tightness shall be ten times the thickness of the thinnest plate connected.

Maximum pitch along uncalked edges of tank plates shall not exceed 30 times the thickness of the thinnest plate connected.

The distance between the center of the outer row of rivets and the edge of plate shall not be less than 1.5 times the diameter of the rivets. Where edges are beveled, the distance from the center of rivets to the toe of the

bevel shall not exceed 1.75 times the diameter of the rivets.

Spacing between rows of rivets shall be as follows:

3.13.1. For joints where one rivet in the inner row comes midway between two rivets in the outer row, the spacing between the rivets or back-pitch shall be $1.75d + 0.185\ (P - 4d)$, with a minimum of $1.75d$.

3.13.2. For joints where two rivets in the inner row are placed between two rivets in the outer row, the back-pitch shall equal $2d + 0.14\ (P - 4d)$, with a minimum of $2d$.

P is the pitch, in inches, of the rivets in the outer row.

d is the diameter of the rivet holes in inches.

3.14. *Riveted Joint Efficiency:* The joint efficiency for riveted joints shall be calculated on the basis of the previously specified unit stresses.

For punched holes the shear and bearing of rivets shall be based on the nominal rivet diameter and the net tension or tearing shall be based on the nominal rivet diameter plus $\frac{1}{8}$ in.

For drilled or subpunched and reamed holes the shear, bearing and tension or tearing shall be based on the drilled or reamed diameter of the holes.

The joint shall be designed and the efficiency determined before adding the corrosion allowance.

3.15. *Weld Design Values—Structural Joints:* Welded joints shall be proportioned so that the stresses on a section through the throat of the weld, exclusive of weld reinforcement, shall not exceed the following percentages of the allowable working tensile stress of the structural material joined.

3.15.1. *Groove Welds:*

Tension	85 per cent
Compression	100 per cent
Shear	75 per cent

3.15.2. *Fillet Welds:* *

Transverse Shear	65 per cent
Longitudinal Shear	50 per cent

* Stress in a fillet weld shall be considered as shear on the throat, for any direction of the applied load. The throat of a fillet weld shall be assumed as 0.707 times the length of the shorter leg of the fillet weld.

3.16. *Weld Design Values—Tank Plate Joints:*

Type of Joint	*Efficiency, per cent*
3.16.1. Double-welded butt joint with complete penetration.	85 Tension; 100 Compression
3.16.2. Double-welded butt joint with partial penetration and with the unwelded portion located substantially at the middle of the thinner plate.	$85\ \frac{Z}{T}$ Tension; $100\ \frac{Z}{T}$ Compression

Where Z is the total depth of penetration from the surfaces of the plate, (use the thinner plate if of different thicknesses);

T is the thickness of the plate, (use the thinner plate if of different thicknesses).

3.16.3. Single-welded butt joint with suitable backing-strip or equivalent means to insure complete penetration.	85 Tension; 100 Compression

Type of Joint	*Efficiency, per cent*
3.16.4. Double-welded transverse lap joint with continuous full-fillet weld on each edge of joint.	75 Tension or Compression
3.16.5. Double-welded transverse lap joint with continuous full-fillet weld on one edge of joint and an intermittent full-fillet weld on the other edge of joint.	$75\frac{(1+X)}{(2)}$ Tension or Compression

Where X is the ratio of the length of intermittent full-fillet weld to the total length of joint, expressed as a decimal.

3.16.6. Lap joint with transverse full-fillet weld, or smaller, on either or both edges of the joint, welds either continuous or intermittent.	$75\frac{(XW_1 + YW_2)}{2T}$ Tension or Compression

Where X and Y are the ratios of the lengths of intermittent welds W_1 and W_2, respectively, to the total length of the joint, expressed as a decimal.

W_1 and W_2 are the sizes of the welds on each edge of the joint respectively.

(W_2 will be zero for a joint welded on one edge only.)

T is the thickness of plate, (use the thinner plate if of different thicknesses).

3.17. *Reinforcement Around Openings:* All openings over 4 in. in diameter in the shell or suspended bottom of the tank shall be reinforced. This reinforcement may be the flange of a fitting used or an additional ring of metal, or both flange and ring.

The amount of reinforcement for a riveted tank shell shall be computed as follows:

3.17.1. In computing the necessary reinforcement of an opening in a tank shell, the net area of the reinforcement shall bear the same ratio to the area of the metal removed from the shell as the strength of the vertical joint in the shell course bears to the strength of the solid plate.

3.17.2. Sufficient rivets shall be used to transmit to the shell plate by shear the full strength of the reinforcing ring or flange, at a maximum unit shear of 75 per cent of unit tensile stress used in designing the shell plate.

The amount of reinforcement for a welded tank shell shall be computed as follows:

3.17.3. The strength of the required reinforcement around an opening in a shell plate shall be based on the vertical cross-sectional area of the metal removed from the plate. This area shall be taken as the product of the vertical diameter of the hole cut in the shell plate and the thickness of the plate (100 per cent reinforcement). The strength through the net cross-sectional area of the reinforcement added, lying in a vertical plane (plane of reinforcement) coincident with the axis of the opening, shall at least equal that of the product referred to above.

3.17.4. The aggregate strength of the welding attaching a fitting to the shell plate and/or any intervening reinforcing plate shall at least equal the proportion of the forces passing through the entire reinforcement that is com-

puted to pass through the fitting considered.

3.17.5. The aggregate strength of the welding attaching any intervening reinforcing plate to the shell plate shall at least equal the proportion of the forces passing through the entire reinforcement, that is computed to pass through the reinforcing plate considered.

3.17.6. The strength of the attachment welding shall be based only on that part of the outer peripheral welding which lies on either side outside the area bounded by vertical lines drawn tangent to the shell opening plus all of the inner peripheral welding that is applied on either side of the plane of reinforcement. This shall be taken as the total shear resistance of the above mentioned attachment welding. The outer peripheral weld shall be made as large as possible and the inner peripheral weld large enough to carry the remainder of the total loading.

3.17.7. In computing the net reinforcing area of a fitting, such as a boiler maker's flange, or a manhole saddle, having a neck, the material in the neck may be considered as part of the reinforcing for a height, measured from the surface of the shell plate or that of an intervening reinforcement plate, equal to four times the thickness of the material in the neck.

Section 4—Design of Standpipes and Reservoirs

4.1. *Standard Capacities:* The standard capacities for standpipes and reservoirs shall be those recommended by the Division of Simplified Practice of the Department of Commerce and shall be as follows:

U. S. Gal.	*U. S. Gal.*
50,000	500,000
60,000	750,000
75,000	1,000,000
100,000	1,500,000
150,000	2,000,000
200,000	2,500,000
250,000	3,000,000
300,000	4,000,000
400,000	

4.2. *Standard Shell Height for Standpipes:* The purchaser shall preferably specify one of the following standard shell heights for standpipes:

Shell Heights from 20 to 50 ft. by even 2-ft. intervals.

Shell Heights from 50 to 100 ft. by even 5-ft. intervals.

Shell Heights from 100 to 200 ft. by even 10-ft. intervals.

The purchaser shall preferably specify the required shell height and the capacity, the exact diameter being determined by the contractor. As here used shell height means height to overflow.

4.3. *Standard Diameters for Reservoirs:* The purchaser shall preferably specify one of the following standard diameters for reservoirs in order to promote standardization of drawings:

Diameters from 20 to 50 ft. by even 2-ft. intervals.

Diameters from 50 to 100 ft. by even 5-ft. intervals.

Diameters from 100 to 200 ft. by even 10-ft. intervals.

For reservoirs the purchaser shall specify the diameter and capacity, the exact height being determined by the contractor.

Section 5—Design of Elevated Tanks

5.1. *Standard Capacities:* The standard capacities for elevated tanks shall preferably be those recommended by the Division of Simplified Practice of the Department of Commerce as follows:

U. S. Gal.	*U. S. Gal.*	*U. S. Gal.*
5,000	60,000	500,000
10,000	75,000	750,000
15,000	100,000	1,000,000
20,000	150,000	1,500,000
25,000	200,000	2,000,000
30,000	250,000	2,500,000
40,000	300,000	
50,000	400,000	

5.2. *Standard Heights for Elevated Tanks:* The height of elevated tank structures shall be measured from the underside of the bases of the steel columns to the lower capacity level. The purchaser shall preferably specify one of the following standard heights:

Heights from 20 to 50 ft. by even 2-ft. intervals.
Heights from 50 to 100 ft. by even 5-ft. intervals.
Heights from 100 to 200 ft. by even 10-ft. intervals.

5.3. *Standard Ranges of Head:* By range of head is meant the vertical distance between the lower capacity level and the overflow between which the required capacity is contained. Where range of head is not material the purchaser shall preferably leave the determination of the range of head to the contractor.

If a special "low" range of head is required the purchaser shall preferably specify ranges of head by even 5-ft. intervals.

5.4. *Columns and Struts:* The column base, whether riveted or welded, shall have sufficient area to distribute the column load over the concrete foundations without exceeding the specified bearing stress on the foundation and the connection of the column to the base plate shall provide for the maximum uplift, if the anchors are connected to the base plates and not to the column shaft.

5.5. *Column Splices:* Column splices shall be designed to withstand the maximum possible uplift, or at least 25 per cent of the maximum compression whichever is greater.

If column splices are riveted, the flanges only of rolled column sections need be spliced. Rolled channels, if used in columns, shall have both the flanges and webs spliced. For welded column splices the joints may either be butt welded or splice plates may be welded to both sections being joined.

5.6. *Bottom Struts:* Bottom struts of steel or reinforced concrete shall be provided where necessary to distribute the horizontal reactions at the bases of the columns. These shall consist of struts connecting the foundation piers, or of structural members connecting the lower ends of the columns.

5.7. *Tension Members Carrying Wind and/or Earthquake Loads:* Such members shall be designed to resist the wind load and the earthquake load if the latter is specified. It is not necessary to combine wind and earthquake loads but to design for the maximum stress produced by either force. If the projected centers of gravity of tension members do not meet the projected center of gravity of structural members at the center of gravity of the columns, proper allowance shall be made for the eccentricity.

Diagonal tension members shall be pre-stressed sufficiently to be taut when the tank is full. Such pre-stressing shall not be given consideration in the design of the members.

5.8. *Horizontal Girders:* For elevated tanks with inclined or battered columns connecting to the tank shell a horizontal girder shall be provided to resist the horizontal component of the column loads.

This girder shall be proportioned to withstand safely as a ring girder the horizontal inward component of the load on the top columns.

If the centers of gravity of the horizontal girder, the top section columns and the tank shell do not meet in a point, provision shall be made in the design of each of them for stresses resulting from any eccentricity.

5.9. *Balcony Railing:* If the horizontal girder is used as a balcony it shall be at least 24 in. in width and shall be provided with a railing at least 36 in. in height.

5.10. *Tank Plates:* Plates for elevated tank bottoms, shells and roofs may be any desired shape. Tank plates shall be designed on the basis of the following maximum fiber stresses which shall be reduced for the joint efficiencies as specified elsewhere in these specifications.

Plate surfaces susceptible to complete stress analysis shall be designed on the basis of a maximum fiber stress of 15,000 psi. Such plate surfaces include those not stressed by the concentrated reactions of supporting members or riser pipes.

Plate surfaces not susceptible to complete stress analysis shall also be designed on the basis of the maximum fiber stress of 15,000 psi. after making reasonable allowances for such loads and stresses as cannot be accurately determined. The maximum fiber stress shall in no case exceed 11,000 psi. when calculated assuming that the concentrated reactions of supporting members are uniformly distributed between such reactions.

For example, consider an elevated tank having a vertical cylindrical shell supported by four columns attached to the shell and having a suspended ellipsoidal bottom with a central riser pipe and a cone roof uniformly supported by the tank shell. Under the meaning of these specifications, the stresses in the cylindrical shell and the ellipsoidal bottom cannot be determined, while those in the roof can be completely determined. The shell and bottom shall be designed on the basis of 15,000 psi. maximum fiber stress reduced for the joint efficiency used making allowances for the following:

5.10.1. The hoop stresses caused by the weight or pressure of the tank contents, assuming that the cylindrical tank shell is uniformly supported on its entire lower circumference.

5.10.2. The stresses in the cylindrical shell and ellipsoidal bottom, considering them acting together as a circular girder supported by the column reactions and subjected to torsion because of the portions projecting outward and inward from the chords connecting the columns.

5.10.3. The horizontal inward component of the pull from the tank bottom (in the case of conical or segmental bottoms) causing compression in the tank shell.

5.10.4. Stresses from any other causes.

After the cylindrical shell and bottom have been designed on the above basis, they shall be redesigned assum-

ing that the cylindrical tank shell is uniformly supported on its entire lower circumference, and for this assumption the thicknesses of shell and bottom shall be increased, if necessary, so that the maximum calculated fiber stress shall not exceed 11,000 psi. reduced by the joint efficiency. In the case of riveted joints the redesign shall be based on the rivet values given in Sec. 3.3 reduced by the ratio of 11,000 to 15,000.

In designing bottoms of double curvature, consideration shall be given to the possibility of governing compressive stresses.

It is recognized that no specifications for the design of elevated tanks can be sufficiently specific and complete to eliminate the necessity of judgment on the part of the designer. It is also recognized that strain gage surveys are a proper source of design information.

5.11. *Steel Riser Pipe:* The steel riser pipe shall be designed to withstand stress caused by the weight or the pressure of the tank and riser contents and also the load imposed upon the top of the riser pipe by the tank bottom or by members supporting the tank bottom. If the design of the riser plates is controlled by hoop pressure, 0.3 of the compression in the vertical direction shall be added to the full calculated tension in the horizontal direction in determining the thickness. If controlled by column stresses the allowable column compressive stress shall not exceed the allowable stress calculated in accordance with Sec. 3.5, minus 0.3 of the calculated hoop stress.

The thickness of the bottom ring of the riser shall be sufficient so that the specified unit stresses shall not be exceeded when combined with bending or other stresses around manhole or other openings.

Section 6—Accessories for Standpipes and Reservoirs

6.1. *Shell Manhole:* A circular manhole 24 in. in diameter or an elliptical manhole 18x22 in. minimum size, with cover hinged to shell shall be furnished in the first ring of the tank shell at a location to be designated by the purchaser.

6.2. *Pipe Connection:* The pipe connection shall consist of a fitting of the size specified by the purchaser, attached to the tank bottom at a point designated by the purchaser, into which the connecting pipe may be calked. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the tank floor and provided with a removable silt stop 6 in. high.

6.3. *Overflow:* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified it shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified it shall be brought down the outside of the tank shell supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser allowing for full suction head. The top stiffener shall not be cut nor partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the

overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. in diameter or over.

6.4. *Outside Tank Ladder:* The contractor shall furnish a tank ladder on the outside of the tank shell beginning 8 ft. above the level of the tank bottom and at a location to be designated by the purchaser, preferably near the manhole. The sides shall be not less than $2 \times \frac{5}{16}$ in. and the rungs not less than $\frac{5}{8}$ in. round or square bars. If a safety cage for this ladder is required by local laws or regulations the purchaser shall so specify.

6.5. *Roof Ladder:* In the case of standpipes with roofs, the contractor shall furnish a roof ladder attached to the roof finial with a swivel connection, the ladder to be equipped with rollers so that it will rotate around the standpipe roof. A roof ladder is not required on standpipe or reservoir roofs having a slope flat enough to walk on safely.

6.6. *Roof Hatch:* For standpipes or reservoirs with roofs, the contractor shall furnish a roof door or hatch, which shall be placed near the outside tank ladder and which shall be provided with hinges and a hasp for locking. The hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

6.7. *Vent:* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

6.8. *Additional Accessories:* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 7—Accessories for Elevated Tanks

7.1. *Tower Ladder:* A tower ladder with sides not less than $2 \times \frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square shall be furnished extending from a point 8 ft. above the ground up to and connecting with either the horizontal balcony girder or the roof ladder, if no balcony is used. The ladder may be vertical but shall not in any place have a backward slope.

7.2. *Outside Tank Ladder:* In all cases, a ladder shall be provided on the outside of the tank shell connecting either with the balcony or with the tower ladder if no balcony is included. The outside tank ladder shall have sides not less than $2 \times \frac{5}{16}$ in. and rungs not less than $\frac{5}{8}$ in. round or square.

7.3. *Roof Hatch:* In all cases, there shall be provided a door or hatch immediately above the high water level, the hatch to be at least 24 in. square and to be provided with suitable hinges and a hasp to permit locking. Hatch opening shall have a curb at least 4 in. high and the cover shall overlap same at least 2 in.

7.4. *Roof Finial:* The roof shall be provided with a suitable finial.

7.5 *Roof Ladder:* Where practicable, there shall be furnished an outside roof ladder designed to rotate around the roof. If desired the roof

ladder may be swiveled about the tank finial.

7.6. *Vent:* In case the tank roof is of tight construction, a suitable vent shall be furnished above the maximum water level which shall have a capacity to pass air so that at the maximum possible rate of the water either entering or leaving the tank, dangerous pressures will not be developed. The overflow pipe shall not be considered to be a tank vent. The tank vent may, however, be combined with the roof finial if desired. The vent shall be so designed and constructed as to prevent the ingress of birds or animals.

7.7. *Steel Riser Pipe:* In localities where freezing temperatures do not occur, the purchaser may specify a small steel riser pipe. In other locations and unless a small pipe is specified a steel riser pipe not less than 36 in. in inside diameter shall be furnished. In cases where the riser pipe supports a considerable load the riser diameter and thickness shall preferably be determined by the contractor.

In all cases where steel risers are used, there shall be furnished a manhole in the riser shell about three feet from the base of the riser, such manhole to be not less than 12x16 in. in size, the opening to be reinforced or the riser plate so designed that all stresses around the opening are provided for.

The above specified minimum riser diameter of 36 in. shall be increased in cold climates unless the riser is heated to prevent freezing. The proper diameter will depend upon the amount the tank is used and the temperature of the water supplied. In extreme cold climates a minimum diameter of 72 in. is recommended.

A safety grating shall be provided in the top of the riser pipe with no opening larger than 6 in. in width, except that a door at least 12x18 in. shall be provided.

7.8. *Pipe Connection:* The pipe connection into which the connecting pipe may be calked, shall consist of a fitting of the size specified by the purchaser, and shall be attached to the riser bottom at a point designated by the purchaser. Unless otherwise specified by the purchaser, the contractor shall furnish the fitting and make the connection to the piping furnished and installed by the purchaser. The top of the fitting shall be flush with the riser floor and provided with a removable silt stop 6 in. high.

7.9. *Overflow:* The tank shall be equipped with an overflow of the type and size specified by the purchaser. A stub overflow is recommended in cold climates. If a stub overflow is specified, it shall project at least 12 in. beyond the tank shell. If an overflow to ground is specified, it shall be brought down the outside of the tank shell, supported at proper intervals with suitable brackets. It shall terminate at the top in a weir box, the weir and connection to the tank to have approximately the same capacity as the overflow pipe specified by the purchaser, allowing for full suction head. The top angle shall not be cut or partially removed. The overflow pipe shall terminate at the bottom with a base ell. Unless otherwise specified by the purchaser, the overflow pipe shall be black steel pipe, with screwed connections if under 4 in. in diameter or flanged connections if 4 in. or over in diameter.

7.10. *Additional Accessories:* Any additional accessories required to be furnished shall be specified by the purchaser.

Section 8—Welding

8.1. *Definitions and Symbols:*

8.1.1. Welding terms employed in these rules shall be interpreted according to the definitions given in the latest edition of "Definitions of Welding Terms and Master Chart of Welding Processes," issued by the American Welding Society.

8.1.2. Symbols used on construction drawings shall conform to those shown in the latest edition of "Standard Welding Symbols," issued by the American Welding Society.

8.2. *Qualification of Welding Procedures and Welding Operators:* All welding procedures and welding operators employed in the construction of tanks under these specifications shall be qualified in accordance with the requirements of the latest edition of the American Welding Society "Standard Qualification Procedure" using the test values and modifying conditions prescribed in Pars. 8.2.1, 8.2.2, 8.2.3 and 8.2.4.

8.2.1. *Qualification of Welding Procedures:* The contractor shall submit a report on the qualification tests of the welding procedures, including all of the types of welded joints in all the positions of welding he intends to use in the construction. These test reports shall bear proper witness certification of a reputable testing laboratory or inspection agency, attesting that such tests were performed in accordance with the requirements of these specifications governing the qualification of welding procedures. Requalification of a welding procedure shall not be required provided that the procedure is not modified in any variable beyond the limits prescribed for that variable in the American Welding Society "Standard Qualification Procedure."

8.2.2. *Groove Welds in Joints Subject to Primary Stress:* (joints subject to primary stress due to weight or pressure of tank contents):

a. Thicknesses greater than 1½ in. shall be qualified in the maximum thickness to be welded. (See Par. 10.7.)

b. Reduced-Section Tension Test—The tensile strength of the welded specimen shall be not less than 95 per cent of the minimum of the specified A.S.T.M. tensile range of the base material.

c. Free-Bend Test—The elongation of the welded specimen shall be not less than 20 per cent.

d. Root-, Face- and Side-Bend Test—Any specimen in which a crack or other open defect is present after bending, exceeding ⅛ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimens during testing shall not be considered.

8.2.3. *Groove Welds in Joints Subject to Secondary Stress* (joints subject to secondary stress and not directly affected by the weight or pressure of tank contents; complete fusion of the joint is not required):

a. Reduced-Section Tension Test—The tensile strength of the welded specimen shall be not less than 110 per cent of the specified strength of the joint.

b. Free-Bend Test—This test shall be omitted.

c. Root-, Face- and Side-Bend Test—These tests shall be omitted.

8.2.4. *Fillet Welds:*

a. Transverse Shear Test—The transverse shear strength of the welded specimen, in pounds per square inch, shall be not less than 87½ per cent of

the minimum of the specified A.S.T.M. tensile range of the base material.

b. Longitudinal Shear Tests—The longitudinal shear strength of the welded specimen, in pounds per square inch, shall be not less than 67 per cent of the minimum of the specified A.S.T.M. tensile range of the base material.

c. Fillet-Weld Soundness Test—Any specimen in which a crack or other open defect is present after bending, exceeding $\frac{1}{8}$ in. measured in any direction, shall be considered as having failed. Cracks occurring on the corners of the specimen during testing shall not be considered.

8.2.5. *Qualification of Welding Operators:*

a. The contractor shall certify that all welding operators employed by him have been qualified as required by these specifications.

b. An operator who has successfully passed the required qualification tests shall be deemed qualified indefinitely, provided: (1) he has not changed his employer; (2) he has been in the meantime continuously employed on similar work, except for periods, no one of which exceeds three months, and with the total idle time not exceeding his working time in each six months' period; and (3) there is no specified reason to question his ability. In case (2) above, the Qualification Test need be made only in the $\frac{3}{8}$ in. thickness.

c. An operator who has been qualified for welding on plates will be permitted to perform the incidental pipe welding required in the fabrication and attachment of tank appurtenances.

d. The contractor shall maintain a record of the welding operators employed by him, showing the dates and results of Qualification Tests and the work-identification mark assigned to each operator.

8.3. *Butt Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks): These joints shall have complete penetration welds, which may be double welded or welded from one side only, using a backing strip or equivalent means to insure complete penetration.

8.4. *Butt Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells): These joints shall be double welded and shall be designed to develop an efficiency of at least 57 per cent, based upon the thickness of the thinner plate joined. Single groove welded joints shall have complete penetration. Square groove and double groove welded joints may have partial penetration, provided the unwelded portion does not exceed one-third ($\frac{1}{3}$) the thickness of the thinner plate at the joint, and provided the unwelded portion is located substantially at the center of the thinner plate. Any joint of this type shall have a strength at least equivalent to two-thirds ($\frac{2}{3}$) that of a double welded butt joint having complete penetration.

8.5. *Lap Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents* (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms of elevated tanks): These joints shall have continuous full-fillet welds on both edges of the joint. (Maximum thickness permitted for this type of joint is $\frac{1}{2}$ in.)

8.6. *Lap Joints Subject to Secondary Stress* (e.g., horizontal joints of cylindrical tank shells): These joints shall be welded on both sides with continuous fillet welds. They shall be designed to develop an efficiency of at least 50 per cent based upon the thick-

ness of the thinner plate joined. Any joint of this type shall have a strength at least equivalent to two-thirds ($\frac{2}{3}$) that of a lap joint having full-fillet welds on both edges. (Maximum thickness permitted for this type of joint is $\frac{5}{8}$ in.)

8.7. *Flat Tank Bottoms Resting Directly on Grade or Foundation:* Bottoms shall be built to one of two alternative methods of construction:

8.7.1. *Lap Joint Construction:* Bottom plates need be welded on the top side only with continuous full-fillet welds on all seams.

Marginal sketch plates under the bottom ring of cylindrical shells, in the case of lap joint construction, shall have the outer end of the joint fitted and welded with groove or fillet welds to form a smooth bearing under the shell. (Maximum thickness for lap welded bottoms shall be $\frac{1}{2}$ in.)

8.7.2. *Butt Joint Construction:* These joints shall be single welded from the top side, using suitable backing strip or equivalent means to insure complete penetration.

8.8. *Shell to Bottom Joint* (applies to vertical cylindrical shells with flat bottoms): The bottom edge of the lowest course shell plates and the bottom sketch plates shall be joined by continuous fillet welds on both sides of the shell plate. The size of each weld shall be equal to the thickness of the sketch plate or the thickness of the shell plate, whichever is smaller, with a maximum size of $\frac{1}{2}$ in. The sketch plate shall extend outside the tank shell a distance of at least 1″ beyond the toe of the weld.

8.9. *Roof Plates:*

8.9.1. Roofs not subject to hydrostatic pressure from tank contents—such roof plates need be welded on the top side only with continuous full-fillet welds on all seams.

8.9.2. Roofs subject to hydrostatic pressure from tank contents—such roof plate joints shall be designed to conform to the efficiency values given in Sec. 3.16.

8.10. *Maximum Thickness of Material to Be Welded:*

8.10.1. The maximum thickness of material to be used for lap joints subject to primary stress due to weight or pressure of tank contents shall be $\frac{1}{2}$ in. (e.g., vertical joints of cylindrical tank shells; all joints below the points of support in elevated tanks).

8.10.2. The maximum thickness of material to be used for lap joints subject to secondary stress shall be $\frac{5}{8}$ in. (e.g., horizontal joints of cylindrical tank shells).

8.10.3. The maximum thickness of material to be used for lap joints in flat tank bottoms resting directly on grade or foundation shall be $\frac{1}{2}$ in.

8.10.4. Butt joints may be used for welding all thicknesses of material permitted to be welded under these specifications.

8.10.5. The maximum thickness of material permitted to be welded under these specifications shall be 2 in. (See Par. 8.2.2. (a) and 10.7.)

8.11. *Minimum Laps for Lap Joints:*

8.11.1. The minimum lap for joints subject to primary stress due to the weight or pressure of tank contents shall be 5 T (e.g., vertical joints of cylindrical tank shells; all joints below the point of support in suspended bottoms).

8.11.2. The minimum lap for joints subject to secondary stress shall be 3 T but not less than 1 in. (e.g., horizontal joints of cylindrical shells, flat tank bot-

toms and roofs not subject to hydrostatic pressure from tank contents).

Where T is the thickness of the material to be welded. In a joint involving two different thicknesses, the thickness of the thinner plate shall be used.

8.12. *Intermittent Welding:*

8.12.1. The length of any segment of intermittent weld shall be not less than four times the weld size but in no case less than 1½ in.

8.12.2. Intermittent welding shall not be used on tank shell plating.

8.12.3. Intermittent groove welds shall not be used.

8.12.4. All seams which are to have intermittent welds shall have continuous lengths of welds at each end for a distance of at least 6 in.

8.13. *Minimum Size of Fillet and Seal Welds:*

8.13.1. Plates $\frac{3}{16}$ in. and less in thickness shall have full-fillet welds. Plates over $\frac{3}{16}$ in. thick shall have welds of a size not less than $\frac{1}{3}$ the thickness of the thinner plate at the joint, with a minimum of $\frac{3}{16}$ in.

8.13.2. Seal welding, when desired, shall preferably be accomplished by a continuous weld combining the functions of sealing and strength, changing section only as the required strength may necessitate.

8.14. *Minimum Length of Welds:*

8.14.1. The minimum length of any weld shall be four times the size, but not less than 1½ in., or else the size of the weld shall be considered not to exceed one-fourth ($\frac{1}{4}$) its length.

8.14.2. The effective length of a fillet weld shall not include the length of tapered ends. A deduction of at least ¼ in. shall be made from the overall length as an allowance for the tapered ends.

Section 9—Shop Fabrication

9.1. *Workmanship:* All workmanship done on tanks being built under these specifications shall be first class in every respect.

9.2. *Straightening:* Any required straightening of material shall be done by methods which will not injure the steel. Straightening by hammering will not be permitted but shall be done cold by rolling or pressing.

9.3. *Laying Out:* Laying out shall be done by experienced workmen only. Rivet holes shall be accurately spaced so that they come opposite each other in adjoining parts. If, upon assembling, holes do not match within $\frac{1}{8}$ in. for punched holes or $\frac{1}{16}$ in. for drilled or reamed holes, the inspector may order the contractor to ream the holes to a larger size and to use larger rivets, or, if the error is too great to permit this, the plate or plates containing such unfair holes may be rejected at the option of the inspector.

9.4. *Rivet Holes:* Rivet holes in material $\frac{5}{8}$ in. thick and under may be punched or drilled full size. Rivet holes in material over $\frac{5}{8}$ in. to and including $\frac{3}{4}$ in. thick shall be either drilled from the solid or punched $\frac{1}{16}$ in. smaller in diameter than the nominal diameter of the rivet and then reamed to size. Rivet holes in material over $\frac{3}{4}$ in. thick shall be drilled.

The final diameter of rivet holes shall be not more than $\frac{1}{16}$ in. larger than the rivets.

9.5. *Plate Edges—Riveted Work:* Edges of plates which are to be calked shall be beveled either by shearing, machining, or cutting with a machine operated gas torch, except that plates over $\frac{5}{8}$ in. thick shall not be sheared.

Plates $\frac{1}{2}$ in. and less in thickness may

be beveled to approximately a 60- to 70-deg. angle. Plates over $\frac{1}{2}$ in. in thickness may be beveled to an angle of approximately 75 to 80 deg.

9.6. *Finish of Plate Edges—Welded Work:*

9.6.1. The plate edges to be welded may be universal mill edges or they may be prepared by shearing, machining, chipping, or by mechanically guided gas cutting, except that edges of irregular contour may be prepared by manually guided gas cutting.

9.6.2. When edges of plates are gas cut, the surface obtained shall be uniform and smooth and shall be cleaned of slag accumulations before welding. All cutting shall follow closely the lines prescribed.

9.6.3. Shearing may be used for material $\frac{1}{2}$ in. or less in thickness to be joined by butt joints, and for all thicknesses of material permitted to be joined by lap joints.

9.7. *Scarfing for Riveted Construction:* Scarfing may be done either by heating the corners to be scarfed to a cherry-red color, then forging while hot, or the scarf may be made by forging in the cold either by hydraulic or mechanical pressing.

9.8. *Rolling:* Plates shall be cold rolled to the proper curvature in accordance with the following table.

Plate Thickness	*Minimum Diameter for Plates Not Rolled*
Plates less than $\frac{3}{4}$ in.	30 ft.
$\frac{3}{4}$ in. to less than $\frac{1}{2}$ in.	60 ft.
$\frac{1}{2}$ in. to less than $\frac{5}{8}$ in.	120 ft.
$\frac{5}{8}$ in. and heavier	Must be rolled for all diameters

All butt straps are to be formed to the proper curvature.

9.9. *Double Curved Plates:* Plates which are curved in two directions may be pressed either cold or hot or may be dished with a "mortar and pestle" die by repeated applications.

9.10. *Milling Columns:* The ends of columns shall be milled to provide a satisfactory bearing unless the design contemplates sufficient riveting or welding to resist the total calculated loads.

9.11. *Shop Assembly:* Double-curved tank bottoms, shells, and roofs, shall be assembled in the shop, if necessary, to insure their fitting properly in the field.

9.12. *Shipping:* All materials shall be loaded on cars, unloaded, transported to the site and stored in such manner as to prevent damage.

Section 10—Erection

10.1. *General:* The contractor shall furnish all labor, liability and compensation insurance, tools, falsework, scaffolding and other equipment necessary and erect the tank complete ready for use. He shall furnish to the purchaser certificates of insurance coverage.

10.2. *Riveted Tanks:* Plates shall be carefully and accurately laid up and shall then be firmly drawn together with machine bolts or wedge bolts before riveting is started.

No paint or foreign materials shall be used between surfaces in contact.

Rivets under $\frac{5}{8}$ in. in diameter may be driven hot or cold. All rivets $\frac{5}{8}$ in. in diameter and larger shall be driven hot.

Hot driven rivets shall be driven by pneumatic or hydraulic tools whenever possible.

Rivets shall be driven with either cone, steeple or button shaped snaps, except that cold rivets may be driven with mushroom heads.

Heads shall be as nearly as possible concentric with the rivet body. All

rivets shall be driven from the side of the plate which calks.

Any burned, loose or defective rivets shall be cut out and redriven.

Riveted seams shall be made tight by calking. The portion of the roof, if any, containing water shall be calked; the remainder of the roof need not be calked. Calking tools and methods used shall be such that the underlying sheet is not damaged and the edge of the top sheet is not turned under. The work must be done by experienced men only.

The opening between ends of plates and outside butt straps shall be stopped by means of a wedge or by welding.

10.3. *Welded Tanks:* If painting is required on underside of flat tank bottom, the bottom plates shall be spread out and painted. After the paint has dried the plates shall be moved to their proper location on the foundations and turned over in place with as little subsequent moving as possible in order not to damage the paint film.

The bottom plates shall be assembled and welded together following a procedure which will result in a minimum of distortion from weld shrinkage.

All shell, bottom and roof plates subjected to stress by the weight or pressure of the contained liquid shall be assembled and welded in such a manner that the proper curvature of the plates in both directions is maintained.

Extra holes in the plates for erection purposes may be used provided the holes are later filled with rivets or weld metal in compliance with Sec. 11.9.

Any clips, jigs or lugs welded to the shell plates for erection purposes shall be removed without damaging the plates and any portion of weld beads remaining shall be chipped or ground smooth.

10.4. *Welds—General:* All welds in the tank and structural attachments shall be made in a manner to insure complete fusion with the base metal, within the limits specified for each joint, and in strict accordance with the qualified procedure.

10.5. *Preparation of Surfaces to Be Welded:* Surfaces to be welded shall be free from loose scale, slag, heavy rust, grease, paint and any other foreign material excepting tightly adherent mill scale. A light film of linseed oil or spatter film compound may be disregarded. Such surfaces shall also be smooth, uniform and free from fins, tears, and other defects which adversely affect proper welding. A fine film of rust, adhering on cut or sheared edges after wire-brushing, need not be removed.

10.6. *Weather Conditions:* Welding shall not be done when the temperature of the base metal is lower than 0° F.; when surfaces are wet from condensation, rain, snow or ice; when rain or snow is falling on the surfaces to be welded; nor during periods of high wind, unless the welding operator and the work are properly protected. At temperatures between 32° F. and 0° F., the surfaces of all areas within 3 in. of the point where the weld is to be started shall be heated to a temperature warm to the hand before the welding is started.

10.7. *Preheating and Interpass Temperature:* When the thickness of materials to be welded exceeds 1½ in., the surfaces within a minimum distance of four times the thickness from the edges where welding is to be started shall be heated to a temperature of 200° F., and at least this temperature shall be maintained for four thicknesses each side of the arc as welding progresses.

10.8. *Cleaning Between Beads:* Each bead of multiple-pass weld shall

be cleaned of slag and other loose deposits before applying the next bead.

10.9. *Tack Welds:* Tack welds used in erection for the assembly of joints subject to primary stress from the weight or pressure of the tank contents and those used for assembling the tank shell to the bottom are to be removed ahead of the continuous welding. Tack welds used in the assembly of joints subject to secondary stress, such as those used in flat bottoms, roofs and circumferential seams of cylindrical tank shells, need not be removed, provided that they are sound and the subsequent beads are thoroughly fused with the tack welds.

10.10. *Peening.*

10.10.1. Peening of weld layers may be used to prevent undue distortion. Surface layers shall not be peened.

10.10.2. Peening shall be performed with light blows from a power hammer using a blunt-nosed tool.

10.11. *Weld Contour.*

10.11.1. In all welds, the surface beads shall merge smoothly into each other.

10.11.2. Undercutting of base metal in the plate adjoining the weld shall be repaired, except as permitted in sections 11.8.7 and 11.8.8.

10.11.3. All craters shall be filled to the full cross-section of the weld.

10.12. *Weld Reinforcement:* The reinforcement of butt welds shall be as small as practicable, preferably not more than $\frac{1}{16}$ in. In no case shall the face of the weld lie below the surface of the plates being joined.

10.13. *Chipping and Gas-Gouging of Welds:* Chipping of the roots of welds and chipping of welds to remove defects may be performed with a round-nosed tool or by gas-gouging.

10.14. *Flat Tank Bottoms:* The bottom plates, after being laid out and tacked, shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding, and to provide, as nearly as possible, a plane surface.

10.15. *Tank Shell:*

10.15.1. For welding in the vertical position the progression of welding shall be either upward or downward, according to the direction specified in the welding procedure and used for operator qualification.

10.15.2. The shell plates shall be joined by welding the joints in a sequence which the contractor has found to result in the least distortion due to shrinkage of the welding and which will avoid kinks at the vertical joints.

10.16. *Matching Plates:*

10.16.1. *Lap Joints:* The plates forming a lap joint shall be held in as close contact as possible during welding, and in no case shall the separation be more than $\frac{1}{16}$ in. Where separation occurs, the size of weld shall be increased by the amount of the separation.

10.16.2. *Butt Joints* (primary stress): In butt joints subject to primary stress from weight or pressure of tank contents, the adjoining plates shall be accurately aligned and retained in position during welding, so that in the finished joint, the center lines of adjoining plate edges shall not have an offset from each other, at any point, in excess of 10 per cent of the plate thickness (using the thickness of the thinner plate if of different thicknesses) or $\frac{1}{16}$ in., whichever is larger.

10.16.3. *Butt Joints* (secondary stress): In butt joints subject to secondary stress, the adjoining plates shall be accurately aligned and retained in position during welding, so that in the finished joint, the thinner plate (if one

is thinner than the other), or either plate (if both plates are of the same thickness), shall not project beyond its adjoining plate by more than 20 per cent of the plate thickness (using the thickness of the thinner plate if of different thicknesses), or $\frac{1}{4}$ in., whichever is smaller.

10.17. *Grouting Column and Riser Bases:* After the tank has been completely erected and trued up, any space which may exist between column and riser bases and foundations shall be thoroughly wetted and filled with a 1:1 cement-sand grout forced under the base plates and filling the space completely. The materials and labor for the grouting are to be furnished by the contractor.

10.18. *Sand Cushion:* A sand cushion not less than 1 in. in thickness shall be provided under riveted flat tank bottoms on concrete slab foundations. The sand shall be furnished at the site by the purchaser and spread by the contractor. In the case of both riveted and welded tanks, after the tank has been completely erected, any space which may exist between the tank bottom and the concrete foundation, and extending for a distance of at least 18 in. inside the tank shell, shall be filled with a 1:1 cement-sand grout forced under the bottom so as to fill completely the space. The top of the foundations shall be thoroughly saturated with water before the grout is poured. The materials and labor for grouting are to be furnished by the contractor.

10.19. *Cleaning Up:* Upon completion of the erection, the contractor shall remove or dispose of all rubbish and other unsightly material caused by his operations and shall leave the premises in as good a condition as he found them.

Section 11—Inspection

11.1. *Riveted or Welded Tanks:* The purchaser may, if he so specifies, require mill and/or shop inspection by a commercial inspection agency, the cost of which shall be paid by the purchaser. Copies of the mill test reports shall be furnished the purchaser if requested.

11.2. *Field Inspection:* It is required under these specifications that the field welding be inspected in the following manner by a qualified welding inspector designated by the purchaser. The contractor shall furnish equipment for trepanning or otherwise obtaining inspection specimens.

The quality of all accessible welds which carry stress from weight or pressure of tank contents shall be inspected by sectioning methods.

11.3. *Application:* The examination of the welded structure by sectioning methods is more satisfactory when applied to butt joints, which makes it highly desirable that the shell of the all-welded tank be constructed with butt joints throughout. While it is possible to cut sections from lap joints, it will require twice as many sections on the double-fillet-welded joints to obtain as many sections per unit length of joint as for butt joints.

11.4. *Sectional Specimens:*

11.4.1. Sectional specimens are segments cut from the welded joints with a circular cutting tool or spherical saw, which removes a portion of the plate bounding the welded joint and exposes thereon two (2) cross-sections of the weld. The segments must

expose the full cross-section of the welded joint.

11.4.2. Segments cut with a circular tool are called trepanned plugs; segments cut with a spherical saw are called spherical segments.

11.5. *Number and Location of Test Segments:*

11.5.1. Removal of sectional specimens shall be confined to tank shell joints, particularly those subject to primary stress from weight or pressure of tank contents. It need not be applied to flat tank bottoms resting directly on grade or foundation, nor to the welds between flat tank bottoms and the first ring of tank shell, nor to the welds connecting top curb angle to shell and to roof, nor to roofs not subject to primary stress from weight or pressure of tank contents, nor to welds connecting manholes and other accessories.

11.5.2. Test Segments shall be taken as the work progresses, as soon as practicable after all the joints accessible from one scaffold position have been welded.

11.5.3. The location for cutting the test segments may be determined by the purchaser's inspector.

11.5.4. Spherical segments shall be cut from the outside of the tank shell for butt joints and from the welded surface for lap joints.

11.5.5. Segments shall be cut from lap joints in pairs, one from each fillet weld. They shall not be removed on the same center line, but shall be offset by approximately 3 in. measured parallel to the axis of the joint.

11.5.6. *Joints Subject to Primary Stress Due to Weight or Pressure of Tank Contents:* One segment shall be cut from the first 10 ft. of completed joint welded by each operator. Thereafter, one additional segment shall be cut from approximately every 100 ft. or any remaining major fraction thereof of joint of the same type and thickness in the structure.

11.5.7. *Joint Subject to Secondary Stress:* One segment shall be cut from the first 10 ft. of completed joint; thereafter, one additional segment shall be cut from approximately every 200 ft. of joint and any remaining major fraction thereof, of the same type and thickness (based upon the thickness of the thicker plate at the joint).

11.5.8. Insofar as practicable, an equal number of segments shall be cut from the welding performed by each welding operator, except where the length of joint welded by an operator is very much less than the average. One segment may be used to test the work of two operators when they have welded opposite sides of the same joint. If such a segment is rejected, subsequent tests of each operator's work shall be used to determine whether one or both operators were at fault.

11.6. *Size of Sectional Segments:*

11.6.1. Segments shall be removed approximately from the center of the weld. The width or diameter of a segment shall be not less than the width of the finished weld, plus $\frac{1}{2}$ in. and in no case less than $\frac{1}{2}$ in.

11.7. *Preparation of Sectional Segments:*

11.7.1. Sectional segments may be etched for inspection by any of the following methods.

(1) Without requiring any finishing or other preparation, place in boiling 50 per cent solution of muriatic (hydrochloric) acid until there is a clear definition of the structure of the weld. This will require approximately 30 min.

(2) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solu-

tion of one part ammonium persulfate and nine parts of water by weight. The solution should be used at room temperature and should be applied by vigorously rubbing the surface to be etched with a piece of cotton kept saturated with the solution. The etching process should be continued until there is a clear definition of the structure of the weld.

(3) Grind and smooth segments with emery wheel and/or emery paper and then etch by treating with a solution of one part of powdered iodine (solid form), two parts of powdered potassium iodide, and ten parts of water, all by weight. The solution should be used at room temperature and should be brushed on the surface to be etched until there is a clear definition of the structure of the weld.

11.7.2. To preserve the appearance of the etched segments they should, after etching, be washed in clear water, the excess water removed, then immersed in ethyl alcohol, and dried. The etched surfaces may then be preserved by coating with a thin, clear lacquer.

11.8. *Inspection of Sectional Segments:*

11.8.1. The etched segments shall be examined to ascertain the extent of weld defects, such as gas pockets, slag inclusions, lack of fusion, undercutting and cracks.

11.8.2. For all welds, the etched surfaces of the segments shall show complete fusion between the weld metal and the base metal within the depth of the weld required for the applicable joint. There shall be no cracks in any weld.

11.8.3. For butt joints, slag inclusions shall not be permissible except where they occur between layers of the weld, are substantially parallel to the plate surface, and are equal to not more than one-half the width of the weld; or where they occur across the depth of the weld and are equal to not more than 10 per cent of the thickness of the thinner plate joined.

11.8.4. For lap joints, slag inclusions shall not be permissible except where they occur between layers of the weld, are substantially parallel to the face of the weld, and are equal to not more than one-half the width of the weld, measured in a direction parallel to the face of the weld; or where they occur across the throat of the weld and are equal to not more than 10 per cent of the throat.

11.8.5. Gas pockets shall not be permissible except where they do not exceed $\frac{1}{16}$ in. in greatest dimension and where there are no more than six gas pockets, not exceeding the maximum permissible size, per square inch of weld metal; or where the combined area of a greater number of gas pockets does not exceed 0.02 sq.in. per square inch (2 per cent) of weld metal.

11.8.6. For butt and lap joints subject to primary stress due to weight or pressure of tank contents, there shall be complete penetration and no undercutting.

11.8.7. For butt joints subject to secondary stress, penetration is only required within the limits established by Sec. 8.4. A maximum undercut of $\frac{1}{32}$ in. at each edge of the weld may be permitted, provided the unwelded portion plus the undercut shall not reduce the thickness of the joint more than $\frac{1}{8}$ of the thickness of the thinner plate joined.

11.8.8. For lap joints subject to secondary stress, the maximum undercut permitted shall be $\frac{1}{32}$ in. deep, measured along either leg of the weld. The maximum amount of lack of penetration permitted at the root of the weld

shall be $\frac{1}{16}$ in., measured along either leg or through the throat of the weld, provided the size of the weld is increased to compensate for lack of penetration.

11.8.9. Where a defective segment is located, additional segments shall be cut from the same operator's work 2 ft. on each side of the defective segment, wherever the joint length will permit. If additional defective segments are found, then more segments shall be cut at intervals of 2 ft. on the same operator's work until the limit of the defective welding has been definitely established; or the contractor may proceed to replace all the welding done by that operator without cutting out additional segments.

11.8.10. Defects in welds shall be removed by chipping or by gas-gouging from one or both sides of the joint and rewelding. Removal of defective welds is required only to the extent necessary to correct the defects present. Repaired welds shall be inspected by repeating the original test procedure.

11.9. *Method of Closing Openings:* Subject to the stated limitations, openings caused by the removal of segments or those made for scaffold brackets or other constructional purposes, may be closed by any of the following methods:

11.9.1. *Openings Cut With a Spherical Saw:* Openings cut with a spherical saw shall be completely filled with weld metal. Fillet welds, where cut, shall be rebuilt to their original contour. In butt joints, a backing plate, if necessary, shall be placed on the inside of the tank shell over the opening; in lap joints, the base material opposite the weld will usually serve as a backing plate.

11.9.2. *Trepanned Plug Openings in Joints Subject to Secondary Stress Only,* or openings not in joints, for scaffold brackets or other constructional purposes: Such openings may be filled by inserting a disc in the hole in a mid-position between the surfaces of the thinner plate for butt joints and in a mid-position of the continuous plate for lap joints. The disc shall be at least $\frac{1}{8}$ in. thinner than the thickness of the thinner plate in the joint and shall have a fairly close fit in the hole. The upper side of horizontal or partially horizontal holes on each side of the disc shall be tapered sufficiently to permit depositing a sound weld in the opening. Both sides of the disc shall be welded over completely, fusing the circular edges of the disc with the plate and making the surfaces of the weld substantially flush with the plate surfaces. Fillet welds, where cut, shall be rebuilt to their original contour.

11.9.3. *Trepanned Plug Openings in Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner plate at the joint, is not greater than one-third ($\frac{1}{3}$) the diameter of the hole: Such openings shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell over the opening, taper the upper side of horizontal or partially horizontal holes, from the backing plate outward, sufficiently to permit depositing a sound weld in the opening. Fillet welds, where cut, shall be rebuilt to their original contour.

11.9.4. *Trepanned Plug Openings in Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner

plate at the joint, is not less than $\frac{1}{4}$, nor greater than $\frac{3}{4}$ the diameter of the hole: Such openings shall be filled completely with weld metal applied from both sides of the tank shell. Before welding, taper the upper side of horizontal or partially horizontal holes, from the center outward, on both sides of the plate, sufficiently to permit depositing a sound weld in the opening. Fillet welds, where cut, shall be re-built to their original contour.

11.9.5. *Trepanned Plug Openings in Butt Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes; where the thickness of the plate, or the thinner plate at the joint, does not exceed $\frac{3}{4}$ in.: Such holes shall be filled completely with weld metal applied from the outside of the tank shell. Before welding, place a backing plate on the inside of the tank shell or a thin disc (not over $\frac{1}{4}$ in. thick) at the bottom of the hole; chip a groove on the outside of the plate, extending from the hole in opposite directions. The length of the groove on each side of the opening is to have a slope of about 1 in $1\frac{1}{2}$ extending from the bottom of the hole to the surface. The groove at the opening shall have sufficient width to provide a taper to the bottom of the hole to permit depositing a sound weld in the opening.

11.9.6. *Trepanned Plug Openings in Butt Joints Subject to Primary or Secondary Stress;* or openings, not in joints, for scaffold brackets or other constructional purposes, for plates of any thickness: Such holes shall be filled completely with weld metal applied from both sides of the plate. Before welding, place a thin disc (not over $\frac{1}{4}$ in. thick) in the hole at the middle of the plate, chip a groove on both sides of the plate, extending from the hole in opposite directions. The length of the groove on each side of the opening is to have a slope of about 1 in $1\frac{1}{2}$ extending from the middle of the plate to the surface.

The groove at the opening shall have sufficient width to provide a taper to the middle of the plate to permit depositing a sound weld in the opening.

11.10. *Record of Segments:*

11.10.1. The segments, after removal, shall be properly stamped or tagged for identification; and, after etching, kept in proper containers, with a record of their place of removal as well as of the welding operator who performed the welding. A record shall be made by the inspector, of all segments, with their identification marks on a developed shell-plate diagram.

11.10.2. After the completion of the structure, the segments may be retained by the purchaser, if he so desires; otherwise they may be discarded.

11.11. *When Inspected:* It is required that the inspector be on the job before any welding is done, at which time the welding operators shall be qualified or their credentials accepted, after which welding may proceed. It is recommended that the inspector make the examination of the trepanned plugs immediately after the first vertical joints are welded to prevent a large amount of unacceptable welding being done which would later have to be removed. The inspector need, however, stay only until he is satisfied that acceptable work is being done, after which he may leave and then return when the welding to be inspected has been completed so that he may complete his inspection of the welds. The inspector shall, however, visit the job at least once during each month that the work is in progress.

11.12. *Who Pays for the Field Inspection:* The purchaser shall pay the cost of the field inspection. If the inspector is required to work a greater number of days, because of repeated tests due to faulty work or of additional trips to reinspect rejected work, the contractor shall pay the increased cost of such inspection over what it would have been if there had been no faulty or rejected work. The inspector shall report to the purchaser any instances where the contractor fails to repair any rejected work which controversy shall be settled between the purchaser and the contractor in a manner satisfactory to them. Upon completion of the work the inspector shall send a written acceptance of the workmanship to the purchaser and at the same time shall send a copy of such acceptance to the contractor.

Section 12—Testing

12.1. *Riveted Flat Bottoms:* Riveted flat tank bottoms shall be tested on horses before being lowered to the grade.* Sufficient water shall be placed in the bottom to cover the bottom angle. Any leaks shall be corrected by calking or redriving rivets, if necessary.

12.2. *Welded Flat Bottoms:* After the bottom has been welded completely, including the attachment of at least the lowest shell course, water, to be supplied by the purchaser, may be pumped underneath the bottom, maintaining a head of at least 6 in. of liquid, by holding that depth around the edge of the bottom inside a temporary dam; or the joints may be tested with a suitable material such as strong soap solution or linseed oil under air pressure or vacuum; or the joints may be tested by the magnetic particle method. The bottom shall be made entirely tight to the satisfaction of the purchaser's inspector.

12.3. *General:* Upon completion of the tank, before it is painted, it shall be filled with water furnished at the tank site by the purchaser at proper pressure to fill the tank to the maximum working water level. Any leaks which are disclosed in this test in either the shell, bottom, or roof (if the roof contains water), shall be repaired by calking for riveted construction and by drilling, chipping or gas-gouging any defective welds and then rewelding for welded construction. No repair work shall be done on any joints unless the water in the tank is at least 2 ft. below the point being repaired.

12.4. *Disposal of Test Water:* The purchaser shall provide means for disposing of test water up to the tank inlet or drain pipe.

Section 13—Field Painting

13.1. *General:* After completion of a satisfactory test, the tank shall be painted or coated in accordance with the purchaser's specifications. See Sec. A7 to A11 inclusive for recommended paints and methods of protecting the tank against corrosion.

13.2. *Workmanship:* All painting shall be done in a workmanlike manner. The surfaces shall be cleaned of foreign material and if no shop paint has been applied, the steel shall be wire-brushed before applying the first coat of field paint.

If the purchaser specifies that the mill scale be removed, and if pickling or sandblasting is not specified, it shall be understood that the rust and loose

mill scale shall be removed by wire brushing only.

13.3. *Painting:* After cleaning, the work shall be given the required number of coats of paint or other materials as specified by the purchaser and in the manner recommended by the manufacturer of such materials. Sufficient time shall be allowed for each coat to dry thoroughly before the following coat is applied.

13.4. *Aluminum Paint:* Where aluminum paint is specified for the exterior of the tank, the contractor shall apply the paint either by brush or spray, at his option, unless the manner of application is specified by the purchaser. The paint shall be applied as smoothly as possible.

Appendix

A1. *General:* This appendix contains recommendations which are believed to represent good practice but they are not to be considered as requirements of the specifications.

A2. *Information to Be Furnished by Purchaser for an Elevated Tank:*

A2.1. Capacity.

A2.2. Height to bottom capacity level or to overflow.

A2.3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).

A2.4. The range of head, if special range is required.

A2.5. Type of joint construction, whether riveted or welded, if there is a preference.

A2.6. Diameter and kind of riser pipe.

A2.7. The desired time for completion.

A2.8. Location of site.

A2.9. Type of road available for access to the site and whether public or private.

A2.10. Name of and distance to nearest town.

A2.11. Name of and distance to nearest railroad siding.

A2.12. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether direct or alternating current. If a.c., what cycle and phase.

A2.13. Availability of compressed air, pressure, volume and charge, if any.

A2.14. Safe bearing value of soil.

A2.15. Corrosion allowance to be added:

A2.15.1. To parts in contact with water;

A2.15.2. To parts not in contact with water.

A2.16. Safety cages required on ladders, if any.

A2.17. Number and location of pipe connections, and kind and size of pipe to be accommodated.

A2.18. Overflow, stub or to ground, and size of pipe.

A2.19. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?

A2.20. Kinds of paint or protective coatings and number of coats:

A2.20.1. Inside surfaces;

A2.20.2. Outside surfaces.

A2.21. Specifications for any additional accessories required.

A3. *Information to Be Furnished by Purchaser for a Standpipe or Reservoir:*

A3.1. If a standpipe, capacity and maximum height of water.

A3.2. If a reservoir, capacity and diameter.

A3.3. Roof pitch and projection at eaves (unless the purchaser wishes to leave to the contractor the selection of proper and appropriate dimensions).

A3.4. Type of joint construction, whether riveted or welded, if there is a preference.

A3.5. The desired time for completion.

A3.6. Location of site.

A3.7. Type of road available for access to the site and whether public or private.

A3.8. Type, thickness and kind of support of roof, if required.

A3.9. Name of and distance to nearest town.

A3.10. Name of and distance to nearest railroad siding.

A3.11. Availability of electric power, who furnishes it, at what charge, if any, what voltage and whether di-

rect or alternating current. If a.c., what cycle and phase.

A3.12. Availability of compressed air, pressure, volume, and charge, if any.

A3.13. Safe bearing value of soil.

A3.14. Corrosion allowance to be added:

A3.14.1. To parts in contact with water;

A3.14.2. To parts not in contact with water.

A3.15. Safety cages required on ladders, if any.

A3.16. Number and location of pipe connections and kind and size of pipe to be accommodated.

A3.17. Overflow, stub or to ground, and size of pipe.

A3.18. Is steel to be sand, grit or shot blasted, pickled or otherwise cleaned of mill scale?

A3.19. Kinds of paint or protective coatings and number of coats:

A3.19.1. Inside surfaces;

A3.19.2. Outside surfaces except underside of bottom;

A3.19.3. Underside of bottom.

A3.20. Specifications for any additional accessories required.

A4. *Information to Be Furnished by Bidder for an Elevated Tank:*

A4.1. A drawing showing the dimensions of the tank and tower including the tank diameter, the height to lower and upper capacity levels, the sizes of principal members and the thickness of plates in all parts of the tank and tower. Also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

A4.2. The number, names and sizes of all accessories included.

A5. *Information to Be Furnished by Bidder for a Standpipe or Reservoir:*

A5.1. A drawing showing the dimensions of the standpipe or reservoir including the diameter, shell height, and the thickness of plates, the type and thickness of the roof, the thickness of the bottom interior and sketch plates, and the sizes or weights of structural members; also, if required by the purchaser, a tabulation showing the rivet data for each type of riveted joint and the welding data for each type of welded joint.

A5.2. The number, names and sizes of all accessories included.

A6. *Drawings:* After award of a contract, the contractor shall prepare foundation plans and detail drawings, such drawings to be submitted to the purchaser for approval before proceeding with any fabrication. Unless prohibited by the purchaser, the steel may be ordered from the design drawings, and, if any changes in capacity or governing dimensions are made by the purchaser which affect the steel ordered, any loss to the contractor shall be assumed by the purchaser. In the preparation of drawings for welded tanks, standard welding symbols as recommended by the American Welding Society shall be used.

A7. *Cleaning and Shop Painting:* The purchaser shall specify the method of cleaning the steel and the type or make of paint or coating material to be used. The following alternative methods are believed to represent good practice:

A7.1. Plates and structural shapes may be sand, grit or shot blasted, or pickled, to remove the mill scale, after which they shall receive a shop coat of an inhibitive steel primer on all parts except contact surfaces and edges to be welded.

A7.2. Plates and structural shapes may be dehydrated with the oxy-acetylene torch, removing such mill scale as becomes loosened with one application of the torch followed by wire brushing, after which all parts shall be given one coat of inhibitive primer while the parts are still warm, except contact surfaces and edges to be welded.

A7.3. Plates and structural shapes may be fabricated and shipped to the erection site without paint, and then shall be erected and allowed to weather until the mill scale is loosened from both interior and exterior surfaces, after which the steel shall be dried, wire brushed and painted with one coat of an inhibitive steel primer on all surfaces. *Note:* This method may be objectionable because of the possibility of mill scale being carried into the distribution system.

A7.4. If no special cleaning is desired, the steel may be painted with an inhibitive primer directly over the mill rolled surfaces, after removing such rust, loose scale and other foreign material as may be removed by wire brushing. The contact surfaces or welding edges should not be painted.

A8. *Field Painting:* After the tank is completely erected, and after it has been tested, interior and exterior surfaces should be cleaned of dirt, rust or foreign material, the welding edges or rivet heads wire brushed, and any abraded spots and all accessible surfaces which were not painted in the shop shall then be spot coated with the inhibitive primer used in the shop, after which the interior and exterior surfaces shall be given the number of coats of paints of the makes or types and colors specified by the purchaser.

A9. *Kind of Paint:* It is recognized that various types and kinds of paint have in great measure demonstrated their suitability for water works use and that no one type or kind is universally applicable. The following are indicative of what is believed to be best practice at present.

A9.1. *Interior Paint:* All interior surfaces of the tank shall be given one coat of interior first coat paint, either in the shop or in the field.

After erection the first coat, if applied in the shop, shall be retouched and all seams and other surfaces not painted in the shop, shall be painted with the same paint.

After the first inside paint coat has thoroughly dried, all inside surfaces shall be given a coat of inside second coat paint in accordance with the formula in Sec. A10.

A9.2. *Outside Surfaces:* All outside surfaces, including all structural members with the exception of the underneath surface of flat bottoms, shall be given one coat of outside first coat paint in the shop or in the field.

After erection, if the first coat was applied in the shop, it shall be retouched with the same paint covering any abraded spots or surfaces which were not painted in the shop, after which all outside surfaces shall receive a second coat of either outside black paint or outside aluminum paint.

A9.3. *Underside of Flat Tank Bottoms:* The underside of flat tank bottoms shall receive a protective coating in the field. If the bottom is riveted, it shall be coated after it has been tested and while it is on horses. If the bottom is welded, the bottom plates may be coated and, after drying, placed in position on the grade or foundation before being welded. The under surfaces may be painted with black asphalt paint or they may be coated with an approved rust-inhibiting high flash-point grease. In the case of welded bottoms, when the grease coating is used, there shall be placed under each seam and under

the shell to bottom connection a strip of asbestos about 6 in. wide which shall be impregnated with the above mentioned rust-inhibiting high flash-point grease.

A10. *Types and Kinds of Paint:* The following paints are suggested as suitable for painting tank structures.

All ingredients of the following paints shall be in accordance with applicable current specifications of the American Society for Testing Materials.

A10.1. *Paint Number 1—Inside First Coat:*

Paste Red Lead	100 lb.
Boiled Linseed Oil	1.625 gal.
Fine Litharge	10 lb.

Beat up the litharge in one quart of boiled oil and add to paint.

Makes about 4.25 gal. of paint.

Paint should be applied without thinning whenever temperatures are high enough to permit thorough, smooth brushing out (about 70° F.). When paint is too thick to brush out smoothly, turpentine may be added, using the minimum amount necessary to secure proper consistency, but in no case to exceed 3 pints of turpentine to 100 lb. of paste red lead. (The above is substantially in compliance with Federal Specifications of the Bureau of Standards TTP-86, adopted September 9, 1939.)

A10.2. *Paint Number 2—Inside Second Coat:*

Same as first with addition of 0.75 lb. of paste lampblack to each batch.

A10.3. *Paint Number 3—Outside First Coat:*

Paste Red Lead	100 lb.
Raw Linseed Oil	2.125 gal.
Drier	1 qt.
Turpentine	1 qt.

Makes about 4.87 gal. of paint.

Note: The above red lead paint formulas are based on paste red lead made by grinding 100 lb. of dry red lead with 8 lb. of linseed oil.

A10.4. *Paint Number 4—Outside Second Coat—Aluminum Finish:*

Pigment—2 lb. Aluminum Paste

Vehicle—1 gal. long oil varnish

The aluminum paste shall comply with the latest revision of A.S.T.M. Specifications D 474 (type A).

Long oil varnish shall comply with the following specifications:

The vehicle shall consist of a long oil varnish, made from ester gum, cumaroneindene, Amberol B1 or F7 or other suitable resins, together with suitable drying oils, and shall fulfill the following requirements:

A10.4.1. The varnish shall be clear and transparent.

A10.4.2. The viscosity shall be between 0.65 and 1.25 poise at 25°C. (77°F.), corresponding to Tubes B to E of the Gardner-Holdt Air Bubble Viscometer.

A10.4.3. The acid number of the vehicle shall be less than 15, based on the non-volatile content of the varnish.

A10.4.4. It shall contain not less than 50 per cent by weight of non-volatile oils and gums.

A10.4.5. It shall pass a 60 per cent Kauri Reduction Test as described in Federal Specification TT-V-81, paragraph F-2g.

A10.4.6. When thoroughly mixed with the aluminum paste specified in the proportion of 2 lb. per gal. of vehicle, the paint shall have good leafing quality, show satisfactory brushing and leveling properties, and shall not break or sag when applied to a vertical, smooth, steel surface.

A10.4.7. The paint shall set to touch in not less than 1 hr. nor more than 6 hr. and dry hard and tough in not more than 24 hr. at a temperature of 20°C. (68°F.) to 30°C. (86°F.).

A10.5. *Paint Number 5—Outside Second Coat—Black Color:*

The paint furnished shall comply with the United States Department of Commerce Circular of the Bureau of Standards, No. 94, U. S. Government Master Specification 14b for ready-mixed paint.

A10.6. *Paint Number 6—Asphalt Varnish for Underneath Surface of Flat Bottoms:*

Paint furnished shall comply with U. S. Government Specification for Asphalt Varnish, Federal Specification Board Standard Specification 19, revised January 2, 1923.

A11. *Electric (Cathodic) Protection of Tank Interiors:* The electrolytic method of protecting water tank interiors has proved to be entirely satisfactory when properly installed and maintained. It is, therefore, recommended for the protection of interior tank surfaces except in cold climates where ice may dislodge the electrodes.

A12. *Foundations—General:* The foundations for elevated tank structures are of considerable importance, because any unequal settlement changes considerably distribution of stresses in the structure and may cause leakage or buckling of the plates. The tops shall be located accurately at the proper elevation. The following is recommended practice with regard to foundations.

A13. *By Whom Designed:* The contractor shall furnish foundation plans based on an assumed soil pressure of 4,000 lb. per sq.ft. for usual conditions. If purchaser's soil bearing value is different from 4,000 lb. per sq.ft., special foundations shall be designed jointly by the purchaser and contractor or their representatives, the purchaser to bear the cost of any required field tests. Foundations shall be installed by the purchaser who shall furnish all materials except anchor bolts. The earth around the foundations shall be regraded sufficiently to permit efficient work during erection.

A14. *Soil Bearing Value:* Unless the purchaser has knowledge of the soil at the tank site, he shall conduct suitable tests to determine the character and safe bearing value of the soil and its condition as regards homogeneity, freedom from old excavation or fill or faults of any kinds.

The following are average soil bearing values:

A14.1. Quicksand and wet alluvial soils, $\frac{1}{2}$ ton per sq.ft.

A14.2. Soft wet clay or sand, 1 ton per sq.ft.

A14.3. Ordinary clay, dry sand mixed with clay, moderately dry sand or firm dry loam, 2 tons per sq.ft.

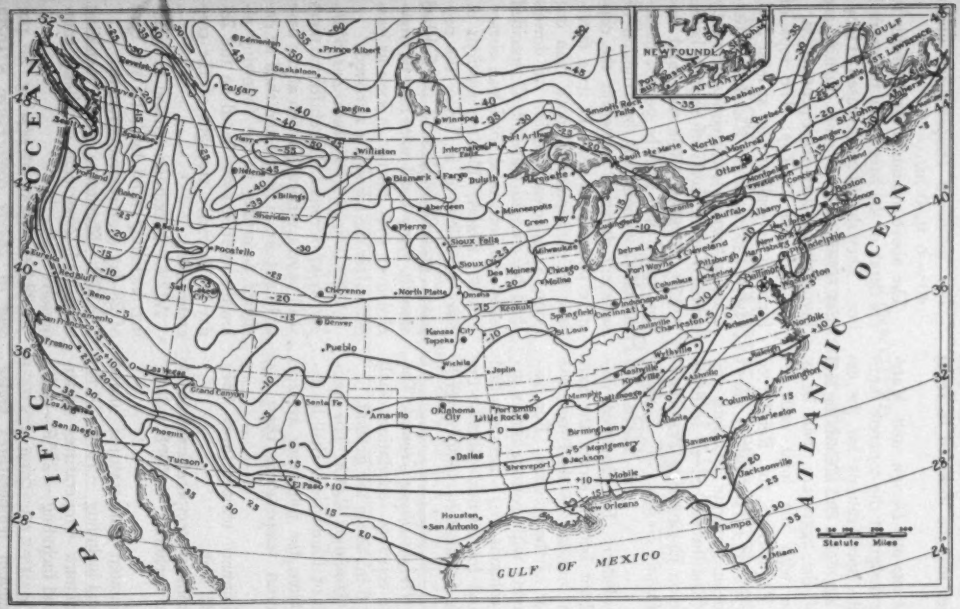
A14.4. Compact coarse sand or hard clay or gravel, 3 tons per sq.ft.

A14.5. Hard pan or shale in horizontal layers and dry, 5 tons per sq.ft.

A14.6. Hard rock, 20 tons per sq.ft.

A15. *Riser Foundations:* Foundations for the riser pipe shall be provided with a tunnel of adequate size to accommodate the base ells for the piping specified by the purchaser. The opening shall be covered with a sufficient thickness of concrete either properly reinforced to support the load on the riser pipe bottom, or steel beams may be provided for this purpose. The foundation beneath the tunnel shall be adequately reinforced. The contractor shall furnish plans for the riser foundation.

A16. *Column Foundations:* Column foundations may be of any suitable shape and may be either plain or reinforced. The weight of the pier shall be sufficient to resist the maximum net uplift occurring with the tank empty and wind load as specified in Sec. 3.2 blowing in the direction causing the



Isothermal Lines—Lowest One-Day Mean Temperatures (Compiled from United States Weather Bureau Records up to 1925); reproduced by permission of the Associated Factory Mutual Fire Insurance Companies

greatest net uplift on any pier. The weight of earth directly above the base of the pier may be included to resist uplift.

A17. *Concrete Design and Materials:* The design of the concrete foundations, the specifications for the cement and aggregate and the mixing and placing of the aggregate shall be in accordance with the joint code of Building Regulations for Reinforced Concrete, Report of Committee E1 of the American Concrete Institute and Concrete Reinforcing Steel Institute Committee on Engineering Practice.

A18. *Detail Design of Foundations:*

A18.1. *Batter:* For battered columns without bottom struts the axis of column foundations shall have the same batter as the column. For battered columns with bottom struts attached to columns or if piers are tied together and for vertical columns the axis of the foundations shall be vertical.

A18.2. *Height Above Ground:* The tops of the concrete foundations shall be at least 6 in. above the ground.

A18.3. *Minimum Depth:* The minimum depth of foundations shall be determined from the minimum average one-day mean temperature chart, as follows:

For minimum temperatures over 32°F.—3 ft. 0 in.

For minimum temperatures under 32° to and including + 10°F.—3 ft. 6 in.

For minimum temperatures under + 10° to and including — 10°F.—4 ft.

For minimum temperatures under — 10° to and including — 20°F.—4 ft. 6 in.

For minimum temperatures under — 20° to and including — 30°F.—5 ft. 0 in.

For minimum temperatures under — 30° to and including — 40°F.—5 ft. 6 in.

For minimum temperatures under — 40°—6 ft. 0 in.

The above minimum depths refer to the depth of the base below the ground line. They should be increased in localities where soil or other factors are favorable for deep frost penetration.

A19. *Size of Top:* The tops of foundations shall project at least 3 in. beyond the column or riser base plates. The top corners shall either be neatly rounded or finished with suitable bevel.

A20. *Pouring:* The riser and column piers shall each be poured monolithically, without any interruption of sufficient duration to permit the concrete partially to set. If it is necessary to pour piers in more than one pour, a sufficient number of dowels shall be used to transmit all specified loads and horizontal wind load shears

A21. *Finish:* The top portions of piers to a level 6 in. below the proposed ground level shall be finished smooth. Any small holes may be troweled over with mortar as soon as possible after the forms are removed.

A22. *Design of Foundations Without Reinforcement:* Unreinforced piers shall have a vertical portion at the base at least 6 in. in height and shall be designed according to the following allowable unit stresses based on the 28-day compressive strength of the concrete used:

A22.1. Maximum tension in bending, including wind load, 1.5 per cent of 28-day compressive strength.

A22.2. Maximum shear, including wind load, 2 per cent of 28-day compressive strength.

A22.3. Maximum bearing, 20 per cent of 28-day compressive strength for dead and live loads or 25 per cent for dead and live loads combined with wind load.

Tentative

Recommended Practice

for

INSPECTING, REPAIRING AND REPAINTING ELEVATED STEEL WATER STORAGE TANKS, STANDPIPES AND RESERVOIRS

This "Tentative Recommended Practice" is based upon competent experience and is intended for use under normal conditions. The procedure is not intended for unqualified use under all conditions. The propriety of following this procedure in any water utility must be reviewed by the authorities responsible for the construction and maintenance of water works facilities in the locality concerned.

Approved as Tentative by:
New England Water Works Association, Sept. 14, 1948
American Water Works Association, Sept. 20, 1948
American Welding Society, *in process*

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This procedural document has been prepared by a standing joint committee representing the American Water Works Assn., the New England Water Works Assn. and the American Welding Society. The committee consists of:

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Tentative Recommended Practice for

Inspecting, Repairing and Repainting Elevated Steel Water Storage Tanks, Standpipes and Reservoirs

Introduction

This document has been prepared by a joint committee of the American Water Works Assn., the New England Water Works Assn. and the American Welding Society. In developing this "Recommended Practice" document, covering the inspection and/or repair and/or repainting of elevated water storage tanks, standpipes and reservoirs, the associations make available to their members an outline of methods which, in the opinion of their committees, may properly be followed.

The principles which the committees feel that the tank * owner should follow in repairing or painting an elevated water tank are listed below. When the term "owner" is used, it may be taken to mean the person or corporation owning the works; the manager or superintendent of the water department or company; the water board or commission; the city council; or the mayor; that is, whoever is responsible for contracts made by and on behalf of the water utility, whether publicly or privately owned.

1. The tank owner should employ a disinterested inspector to look over the metal surface inside and out, to determine the condition of the paint and interior metal surfaces, and what repairs, if any, are needed. Tanks need repainting frequently, but, if properly maintained, repairs are rarely necessary.

2. The owner should invite any tank painting or repair firm which he wishes to bid on a job to inspect the tank at the same time the inspector does, so that the prospective contractors have full information concerning the conditions.

3. The owner should have the tank drained, cleaned and dry, ready for inspection, on the announced date. (*See* Part A, Sec. 2A–1.4.)

4. The owner should draw up his own proposals for the work to be done and request bids on the work. He should have these proposals approved by his attorney.

5. The tank owner should not combine proposals for repair work and painting in one document. He should always leave himself free to award separate contracts if he desires.

6. The owner should not permit any bidder to condition one part of the operations upon another part. For example, the owner should not permit a painting contract to bear any conditions, reservations or cancellations of customary guarantees dependent upon the same bidder receiving the contract for repairs.

* The word "tank" is used hereinafter broadly in place of the lengthy phrase "elevated steel water tanks, standpipes and/or steel water storage reservoirs."

7. The owner should, however, include in his proposal a provision that, if the contracts for repairs and for painting are granted to the same contractor, the contractor shall record the amount which he will deduct from the sum of the two independent bids. (The price for the combination job should be less by the stated amount than the sum of the same contractor's bids for separate jobs.)

8. The owner should compare all bids received to see whether a separate bid by one contractor for repair and a separate bid by another contractor for painting total less than the adjusted bid in 7 above. If the saving is material and if both the contractors are known to be reliable, separate contracts should be let.

9. The owner, particularly if a municipal department, should arrange for public review of bids and for public letting of contracts.

10. If the owner chooses to engage in letting contracts for painting and repair on contract forms other than his own, he should first submit them to his attorney, asking him to study them carefully to see:

a. that no unlimited unit price commitments are included in the contract form;

b. that no commitments or guarantees by the contractor are conditioned upon any matters not clearly and specifically set forth in the contract;

c. that no obligations are incurred by the owner which are not specifically set forth in the contract; and

d. that a clause covering possible extra work is included in the contract form and is of the same general character and equally as specific as that included in Sec. 2B–2 of the "Recommended Practice for Repairs" (Part B of this document).

Referring to 10a above, it is clearly in the interest of equitable business practice that, if the owner and the contractor agree to permit or authorize the contractor to do some unscheduled repair work incidental to painting, this repair work should not be of such extent as to make the painting cost minor by comparison. Again, upon the assumption that a tank owner may choose to disregard the recommendations for prior inspection outlined above, he can properly, and should, stipulate that the total of unscheduled repairs shall not cost more than a given amount, such as the total of the painting contract.

Referring to 10b and 10c above, it is observed that, if extended beyond one year, guarantees of repair or painting work done involve uncertainties which are not necessarily in the interest of either the tank owner or the repair or painting contractor. Frequent and periodic inspection of a water tank is proper and useful, but it should not result in the owner's commitment to a contract for work to be done at an uncertain future date or at a price not arrived at by proper competition.

Since this document relates primarily to painting, the body of the text includes no reference to other methods of protecting metal surfaces.

The electric (cathodic) method of protecting the submerged area of water tank interiors by the use of electrodes suspended in the water has proven satisfactory under most conditions when properly designed, installed and maintained. Cathodic protection failures have occurred principally in cold climates where ice has dislodged the electrodes, or in tanks storing waters with wide fluctuations in alkalinity. Cathodic protection, like specific paints, has varying applicability to various waters.

If contemplated for inside protection, the equipment should be selected only after technical consideration of the particular water to be stored. A combination of cathodic protection and painting of the surface ordinarily gives the best results. When calling for bids on cathodic protection systems, bidders should be asked to state the capacity of the power unit and the material, number and length of electrodes to be used.

By the issuance of this procedural document, it is not implied that water departments or companies are not, on their own initiative, competent to develop equitable contracts. Neither is it implied that any member of the associations involved is required to use the procedure herein outlined. The associations have no power or intent to stipulate that a precise procedure must be followed in any phase of water works operation and maintenance. The associations, likewise, are not in a position to police the entire field of contractual operations of water departments and companies. They must content themselves with providing for their members what is considered the best information available on any subject which is documented. It must remain with the responsible executives in the water department or company to protect the interest of the community which they serve.

Tentative Recommended Practice for

Inspecting Elevated Steel Water Storage Tanks, Standpipes and Reservoirs

Section 2A–1—General

Sec. 2A–1.1—Scope

Every elevated steel water tank, standpipe or reservoir should be carefully inspected prior to repair and/or repainting and at any time when leakage or some other apparent deterioration is observed. In any event, all elevated water tanks should be thoroughly inspected at intervals of not more than five years. It is the intent of this document to define the requisite qualifications of the inspecting agency, the type of inspection to be made and the data considered essential.

Sec. 2A–1.2—Inspection Service

Under the terms of this recommended practice document, inspection service shall be provided only by organizations or individuals who are properly qualified to do such work. Those so qualified are:

(1) An engineering organization whose principals are registered professional engineers, specializing in inspection service and having at least five years' experience in the inspection of steel structures

(2) Independent engineers, licensed in the state in which the structure is located, whose practice has included substantial or major attention to steel construction

(3) Inspection or safety agencies of the state in which the structure is located, if such agencies are empowered to render inspection service and, further, if such inspection services involve the employment of personnel experienced in steel construction and maintenance.

In all of the above classes of qualified inspection agencies, the inspector or inspectors assigned to the work in the field shall have been properly trained by the organization so qualified and shall have no interest, other than that of a competent inspector, in the performance of any work under consideration at the time the inspection is made.

Sec. 2A–1.3—Responsibility

The inspector shall assume the entire responsibility for accident to himself while inspecting the structure. He shall make such observations of ladders, railings, roof rods and other parts of the structure as may be necessary to determine their safety for use by him in inspecting the structure. The inspecting company or inspector shall carry adequate workmen's compensation, property-damage and public-liability insurance and shall fully protect

the owner against claims of any nature arising out of the inspection work.

Sec. 2A–1.4—Draining of Tank

The owner, following proper notification, shall have the tank emptied for the inspector in order that the inside of the roof, sides and bottom of the tank will be properly exposed for inspection. The inside surfaces shall be thoroughly washed down by the owner, who shall have all slime removed from wall surfaces and loose deposits and dirt removed from the tank bottom before the inspector arrives. *This is essential.*

Sec. 2A–1.5—Work Included

The work included under this inspection shall consist of: (1) a field examination; and (2) a specific report upon the structure, using the information form which is a part of this document (Sec. 2A–2 and 2A–3) supplemental wherever necessary to fit peculiar local conditions. The inspection work does not include repairs, *except* that, if cotter pins or nut pins are found to be missing, they shall be replaced at once, or else a special report shall be made promptly to the owner so that he may have the pins replaced.

TABLE 1

Pitting Report

Location (by plates numbered from roof down)	Per Cent of Area Affected (approx.)	Max. Depth of Pitting Found	Type of Pitting	Plate Thickness
1				
2				
3				
etc.				
bottom				

Section 2A–2—Examination and Report

Sec. 2A–2.1—Condition of Paint

Under the general heading "Condition of Paint," give a description of the condition of the paint as found, stating:

(1) Approximate per cent of rust area

(2) Special locations of such areas, if segregated

(3) Character of such rust areas—that is, whether general or blotchy corrosion, loose paint or none

(4) Whether the rust can be removed by wire brushing, to provide a satisfactory surface for painting.

Sec. 2A–2.2—Pitting

Determine and report upon the extent and depth of pitting. The extent should be described both as to location and character. The record of depth of pitting should be specific as to location, area affected, whether blotchy, deep, pin-point or general corrosion. Depth gages should be used to obtain specific data. Report as in Table 1.

If plates are badly pitted, report whether drilling holes to determine the plate thickness is recommended.

Sec. 2A–2.3—Type of Repairs

Where pitting has penetrated to a depth indicating the necessity for repairs, the report shall so state specifically, describing the location of such spots and their size. If they can be repaired by patches, the inspector shall specify the size, location and number

of patches. If other types of repairs are indicated, the inspector shall specify clearly the type and extent recommended. (Use the same plate reference numbers as in Table 1.) The inspector, in his report, shall inform the owner of all repair work which he considers necessary. The report need not be limited to the items specifically outlined herein, but should include all items of any nature which the inspector considers material.

Section 2A–3—Detailed Report of Inspector

Sec. 2A–3.1—Items to Be Reported

In addition to the descriptive report outlined under Section 2A–2, the inspector shall report on the details itemized below.

3.1.1—Anchor Bolts

(1) Are the anchor bolts rusted so as to reduce their strength materially? If so, caliper and record the smallest section. Advise replacement if considered necessary.

(2) Are the anchor bolt nuts tight?

3.1.2—Column Shoes

(1) Are the column shoes clean and painted?

(2) Has dirt accumulated?

(3) Are the column shoes seriously rusted? If so, where and to what depth?

3.1.3—Tower

(1) Are the tower posts in line?

(2) Is there any indication of settlement in the foundations?

(3) Are the tower rods in good adjustment and well turned up?

(4) Are the tower rods in good condition? If badly rusted, measure the smallest part and report, indicating rods on which reduced section occurs. (Advise replacement if considered necessary.)

3.1.4—Cotter Pins

(1) Examine each pin for the presence of cotter pins. Report the location of any pins not so fitted.

(2) Where rod pins with nuts are used, advise if the nuts are on with full thread and the end of the thread is well battered.

3.1.5—Riser Pipe

(1) Is the riser pipe straight?

(2) Are the riser pipe stay rods in good condition?

(3) Is the frost casing in good condition and properly supported?

3.1.6—Indications of Leakage

(1) Are there any indications of leakage in the riser pipe?

(2) In the expansion joint?

(3) In the tank proper? If so, give the location and state the type of repair indicated.

3.1.7—Ladder

Is the ladder safe?

3.1.8—Balcony

(1) Is the balcony safe?

(2) Is the balcony floor in good condition?

(3) State the amount of rust accumulated on the balcony floor.

3.1.9—Bolts

Are any bolts or rivets omitted or missing in the spliced connections of the tower, struts and balcony?

3.1.10—Paint

Report on each of the following items:

(1) The condition of the paint and metal of the tower

(2) The condition of the paint and metal on the outside of the tank bottom, particularly underneath the balcony and post connections

(3) The condition of the paint and metal outside of the tank shell

(4) The condition of the paint and metal outside of the roof and under the eaves of the roof

(5) The condition of the paint and metal inside of the tank shell (Each sheet shall be carefully examined, removing enough of the accumulation of scale and rust to enable the inspector to report in detail the exact condition of the metal underneath and the extent of rust and pitting.)

(6) The condition of the paint and metal on the inside of the roof

(7) The condition of the spider and spider rods

(8) The finial connection. (Is it solid and safe for the attachment of the painter's trolley?)

(9) The condition of the paint and metal on the inside of the bottom

(10) The condition of the paint and metal inside of the riser pipe, particularly at the bottom.

3.1.11—Rivets

Report the condition of the rivets at lap joints and post connections.

3.1.12—Metal

Report the condition of the metal between the rivets at the laps and at the post connections.

3.1.13—Tank Bottom

Has the bottom of the tank deteriorated because of its having been covered with mud or scale? If so, what conditions are observed? Will scaling and repainting be satisfactory? Are repairs indicated? If so, describe in detail.

3.1.14—Prior Painting

(1) When was the tank last painted?

(2) What material was used?

Sec. 2A–3.2—Disposition of Report

3.2.1. Two copies of the inspection report shall be delivered to the owner.

3.2.2. It is understood between the owner and the inspection company that copies of the inspection report may be made available by the owner to painting or tank repair contractors, to define the condition of the tank, if bids for repair or painting are desired.

Sec. 2A–3.3—Payment

Payment for the above specified services, including all expenses of the inspector, shall be at the lump sum price agreed upon between the owner and the inspector. Payment shall be made within thirty days after the receipt of the inspection report.

Section 2A–4—Cleanliness

The inspector shall conduct all his work in a clean and sanitary manner.

No one shall work in a tank if he has been under a physician's care, or has needed a physician's care, within a seven-day period prior to entering or working in the tank. No person shall be permitted to work in a tank who has an abnormal temperature or gives evidence of illness. The tank owner, or a physician employed by him, shall be the judge of the physical fitness

or unfitness of any person to enter or work in a tank. No deviation from this stipulation may be permitted.

The tank owner, after work of any nature is done in a tank, is charged with satisfying himself that the tank interior is clean and sanitary before the tank is returned to service. Although a contractor may be required by his contract to clean all surfaces thoroughly before a tank is restored to service, it is the ultimate responsibility of the tank owner either to give the tank a final field inspection or to require such laboratory tests of the quality of water held (for test purposes) in the tank as will demonstrate the good sanitary condition of the tank interior. (See the note on disinfection procedure at the end of Part C of this document.)

Part B 7H.2-T

Tentative Recommended Practice for

Repairing Elevated Steel Water Storage Tanks, Standpipes and Reservoirs

Introduction

Every tank repair job should be preceded by a detailed inspection of the structure and a report by a competent inspector. Part A of this document deals with inspection. Only from such an inspection is it possible for the tank owner to determine the character and extent of the repairs needed. Without such a determination, it is impossible to define the repair work to be done so that prospective bidders can estimate the cost of the repairs and submit economical proposal therefor.

The owner, using the inspector's report as a basis, shall define and list the repairs to be made. Bids should be made on a fixed-price basis.

It is recognized that specifications for repair work must necessarily be rather general, but the following is recommended as likely to secure good work from responsible bidders at reasonable and definite cost.

Section 2B–1—General

Sec. 2B–1.1—Work to Be Done

The specifications and contract shall cover all repair work to be done and all compensation to be paid or received therefor. There shall be no other agreements relating either to the work or to compensation.

Sec. 2B–1.2—Inspection Recorded

The owner shall advise that he has had the structure inspected (naming the inspector) and that a copy of the inspection report is available. The bidders shall familiarize themselves with the report and the conditions of the

structure, and, upon request to the owner, may make such further inspection as they consider necessary, prior to submitting proposals.

Sec. 2B–1.3—Work to Be Itemized

The owner shall itemize repair work by units, such as the number of patch plates to be welded to the structure and their average area; the lineal feet of welding to make the seams watertight; the spider rods to be replaced; the new roof or parts to be replaced, and so forth.*

It is recommended that, in general, welding on tank plates to replace impaired thickness be limited to filling of pits; and that extensive welding over the surfaces of plates or of riveted seams be carefully considered and used only where replacement will not be practicable. All welding performed in the replacement of plates or broken parts, or for other repairs, shall be performed in accordance with the welding provisions given in A.W.W.A.-N.E.W.W.A.-A.W.S. Standard Specifications for Elevated Steel Water Tanks, Standpipes and Reservoirs (7H.1–1943).

Sec. 2B–1.4—Lump Sum Bids

Bids shall be on a lump sum basis, including all the contractor's costs, such as transportation, labor, tools, equipment, insurance, delays or other costs of any nature growing out of the repair work above defined.

Section 2B–2—Extra Work

No payment shall be made for any work other than the lump sum amount bid by the contractor, except upon written order of the owner or his authorized representative, *prior to the beginning of the work for which extra compensation is to be requested.* When extra work is so authorized, compensation therefor shall consist of actual wages paid to labor thereon; plus the actual cost of materials used in the extra work; plus an allowance equal to 25 per cent of the sum of this labor and material cost, which percentage shall be the only amount to be paid in addition to said costs. No claim for equipment rentals, delays, insurance and similar items shall be made or allowed. All such items are embraced in the 25 per cent to be allowed as stated above.

** Rivets—For a great many years, it was the custom for tank manufacturers to drive tank rivets with flat heads on the inside. After a number of years, a flat-head rivet, which may have rusted to some extent, appears to have lost the major portion of its head, when, in reality, only a small part has disappeared and the rivet has many years of life left. As rivets do their work in shear and as there is very little tension force on a rivet, the head can rust nearly away before replacement is necessary. As long as a rivet stays tight in its hole, it fulfills its function and does not have to be replaced.*

Section 2B–3—Watertightness

All work shall be done by experienced workmen, using equipment best adapted to the work. Upon completion of the repair work, the structures shall be watertight. Repair work shall be neatly done. Payment for repair work shall not be made until and unless the job is watertight.

Section 2B–4—Responsibility

The contractor shall carry adequate insurance—property, public and employers' liability—and shall protect the owner against suits of any nature which may arise out of work performed by the contractor.

Section 2B–5—Inspection

The owner shall inspect the repair work as it is being done or employ an inspector to do so. Payment for work done shall be made only after the owner has satisfied himself directly that the work is satisfactory; or after an inspector's report has been filed with the owner certifying that the work has been done properly and in accordance with the terms of the contract.

It is in the mutual interest of the owner and the contractor that such inspection be made promptly.

Section 2B–6—Cleanliness

The contractor and all workmen employed by him shall conduct all operations in a clean and sanitary manner. No nuisance shall be committed in a tank; the workmen shall either use proper waste receptacles or leave the tank whenever necessity arises.

No one shall work in a tank if he has been under a physician's care, or has needed a physician's care, within a seven-day period prior to entering or working in the tank. No person shall be permitted to work in a tank who has an abnormal temperature or gives evidence of illness. The tank owner, or a physician employed by him, shall be the judge of the physical fitness or unfitness of any person to enter or work in a tank. No deviation from this stipulation may be permitted.

The tank owner, after work of any nature is done in a tank, is charged with satisfying himself that the tank interior is clean and sanitary before the tank is returned to service. Although a contractor may be required by his contract to clean all repairs thoroughly before a tank is restored to service, it is the ultimate responsibility of the tank owner either to give the tank a final field inspection or to require such laboratory tests of the quality of water held (for test purposes) in the tank as will demonstrate the good sanitary condition of the tank interior. (See the note on disinfection procedure at the end of Part C of this document.)

Part C 7H.2-T

Tentative Recommended Practice for

Repainting Elevated Steel Water Storage Tanks, Standpipes and Reservoirs

Section 2C–1—General

Sec. 2C–1.1—Repairs Not Included

Painting contracts shall cover no repair work. No payments for repair work shall be made under painting contracts.

Sec. 2C–1.2—Damage to Tank

The painting contractor shall use care in his work not to injure the tank in any way. He shall use no hammer on the tank in excess of 3 lb. in weight. If, in the process of removing old paint or carrying out the work specified in the contract, any leaks develop, they shall be repaired by the painting contractor without additional remuneration; or, if the owner so elects, by another contractor to be employed and paid by the owner. In the latter case, it is expressly understood that the painting contractor shall not claim, nor shall the owner be liable, for costs resulting from the delay in having the repair work done, but the owner shall use diligence in having the repair work done promptly.

Sec. 2C–1.3—Work to Be Done

The contractor shall commit himself to furnish all labor, machinery, tools, rigging, brushes and all cleaning and painting materials necessary to clean and paint the structure in strict conformity with the requirements of the specifications.

Sec. 2C–1.4—Inspection Recorded

The owner shall state that he has had the structure inspected, naming the inspector. The inspector's report on the condition of the structure shall be made available to bidders. The owner, upon request, may given prospective bidders ample opportunity to conduct their own inspection in order to verify the inspection covered by the report.

Sec. 2C–1.5—Lump Sum Bids

Bids shall be on a lump sum basis, including all the contractor's costs, such as transportation, labor, tools, equipment, materials, insurance, delays or other costs of any nature growing out of the painting work above defined.

Sec. 2C–1.6—Extra Work

No payment shall be made for any work other than the lump sum amount bid by the contractor, except upon written order of the owner or his authorized representative, *prior to the beginning of the work for which extra compensation is to be requested.* When extra work is so authorized, compensation therefor shall consist of the ac-

tual wages paid to labor thereon; plus the actual cost of materials used in the extra work; plus an allowance equal to 25 per cent of the sum of this labor and material cost, which percentage shall be the only amount to be paid in addition to said costs. No claim for equipment rentals, delays, insurance and similar items shall be made or allowed. All such items are embraced in the 25 per cent to be allowed as stated above.

Section 2C–2—Preparation of Surfaces

Shot blasting, sand blasting, power-driven scaling tools, flame cleaning and brush cleaning are methods commonly used for cleaning steel surfaces prior to repainting. The first three are preferred on account of their superior results, particularly in cleaning the rust, corrosion and old paint out of pits.

Sec. 2C–2.1—Brush Cleaning

If the old paint is in good condition, adheres tightly to the steel and is hard and not too thick, it may be left on. All rust, loose mill scale and loose paint shall be removed by means of scalers or scrapers *and* wire brushes (preferably power driven), emery cloth or sandpaper, and either air or cloth dusters. Special care shall be used to clean all pits and roughened areas. In places where blisters or rust has occurred, the steel shall be cleaned until it is bright, either by wire brushes and scrapers or by the use of hand or power sanders. All foreign material, rust and loose paint shall be removed, and any old paint which has been allowed to remain shall have a clean surface and be tight to the steel.

All rust, scale and sediment collected inside of the tank bottom shall be entirely removed from the tank and the inside surfaces swept clean. In cleaning elevated tanks, such rust, scale, etc., shall be lowered to the ground by acceptable means and disposed of in a manner satisfactory to the tank owner.

Sec. 2C–2.2—Shot- or Sand-Blasting

When shot- or sand-blasting equipment is available, or when the condition of the steel is such that the methods described in Sec. 2C–2.1 are incapable of properly cleaning the steel preparatory to painting with red lead (and always in connection with the preparation of the surface for the application of coal-tar enamel coatings or for wax-grease type protection), all surfaces shall be cleaned by shot or sand blasting. The shot- or sand-blasting equipment shall have ample capacity to furnish the required volume of compressed air to operate the blast effectively. The air shall be free of oil or moisture. If sand is used, it shall be principally composed of silica grains and shall be as coarse as it is practicable to use. Provision shall be made to prevent the spreading of sand to adjoining property. Steel grit may be used in lieu of sand at the option of the contractor.

Whatever metal is cleaned by sand blasting *on any day* shall be coated with primer *on the same day*. If rust forms on any sand-blasted surface from any cause, the surface shall be recleaned, as necessary, before the application of primer.

After cleaning, all surfaces shall be wiped free of any dust resulting from such cleaning.

Section 2C–3—Paint

Before any type of primer or paint is applied to the steel surfaces, steps shall be taken, either by the circulation of air or by the application of heat, to dry the metal surface completely.

Sec. 2C–3.1—Kind of Paint *

It is recognized that various types and kinds of paint have in great measure demonstrated their suitability for water works use and that no type or kind is universally applicable. The types of paint which have in general given the best service, and which are believed to represent the best practice at the present time, are: (1) red lead and oil, (2) red lead and synthetic resin, (3) coal-tar enamels and (4) wax grease.

Sec. 2C–3.2—Lead and Oil Paint

For repainting rough surfaces, three-coat work is ordinarily recommended. Two-coat work is satisfactory where surfaces are smooth and full coverage is practicable without "holidays." Only when the old paint is in good condition, except for minor spots which can be touched up satisfactorily, is a single coat acceptable.

Although red lead in linseed oil is still recognized as one of the best protective coatings for steel, its use has largely been superseded by red lead in the more rapid drying water-resistant synthetic resin (phenolic) varnish, which is specified herein for interior use.

3.2.1—Interior Paint

If the interior surfaces have been previously unpainted, or if the old paint has been completely removed and the surfaces have been carefully prepared, a minimum of three coats of paint should be used. Alternate coats of the same paint should be tinted slightly by the addition of a small quantity of lamp black or iron blue in order that full coverage with each application will be assured.

On a previously painted surface where the old paint is generally in good condition except for minor failed areas, these areas should be touched up with two coats of the paint and the entire surface then given a full coat.

All interior surfaces of the tank shall be painted with (or touched up with) paint complying with Federal Specifications of the Bureau of Standards TT–P–86a, Type IV, with all subsequent amendments, if any. The paint shall set to touch in not more than one hour and shall dry through in less than six hours.

Paint shall be delivered to the job in original containers marked with the name of the manufacturer and the type and quantity of materials contained therein.

The paint shall not show excessive settling in a freshly opened full can and shall easily be redispersed with a paddle to a smooth, homogeneous state. The paint shall show no curdling, livering, caking or color separation and shall be free from lumps and skins.

The paint as received shall brush easily, possess good leveling properties and show no running or sagging tendencies when applied at a spreading rate

* Since it has not been possible to obtain from the Asphalt Institute, the Federal Specifications Board or the American Society for Testing Materials a standard specification for an asphaltic paint, such material is not included in this document.

of 500 sq.ft. per gallon to smooth steel vertical surfaces.

The paint, when reduced with not more than one part by volume of mineral spirits (conforming to Federal Specification TT–T–291a, Grade I) to eight parts of the package material, shall spray satisfactorily, show no tendency to orange-peel, sag, creep or run, and show spraying properties in all other respects.

The paint shall not skin within 48 hours in a three-quarters-filled closed container.

The paint shall dry to a smooth uniform finish, free from roughness, grit, unevenness and other surface imperfections. The paint shall show no streaking or separation when flowed on clean glass.

When exposed to cold distilled water, as specified in Federal Specifications TT–P–86a (Sec. E–5j and F–2b), the film of paint shall show no blistering or wrinkling immediately upon removal of the panel. There shall be no softening of the film and no more than a slight whitening when examined two hours after removal.

3.2.2—Outside Surfaces

Outside surfaces which have been previously unpainted or from which all the old paint has been removed should receive two complete prime coats. The second coat should be altered slightly by the addition of lamp black or iron blue in order that full coverage may be assured. On previously painted surfaces, where the old paint is generally in good condition except for minor spots, these spots should be patch coated with one or two coats of the primer, prior to the application of the finish-coat paints.

The outside prime coat, or the patch coat, shall comply with Federal Specifications TT–P–86a, Type I, which require the use of red lead in linseed oil weighing not less than 24 lb. per gallon.

Paints based on the following specifications have demonstrated their usefulness for outside finish coats:

White—Federal Specifications TT–P–40, Amendment 2, Type I, Class A (white lead-titanium dioxide-zinc oxide-extender-linseed oil)

Tint Base—Federal Specifications TT–P–40, Amendment 2, Type I, Class C (same as Class A, but nonchalking rutile type titanium dioxide specified)

Black—Federal Specifications TT–P–61a (red lead-carbon-extender and/or iron oxide-linseed oil)

Aluminum—Federal Specifications TT–V–81a, Type II, Class B ("Varnish; Mixing for Aluminum Paint") and TT–A–468, Amendment 3, Type II, Paste Grade I, Class A ("Aluminum Pigment: Powder and Paste"); mix 2 lb. of aluminum paste and 1 gal. of aluminum mixing varnish

Foliage Green—State of Maine Highway Dept.; the formula for this paint is as follows:

Finish Coat—Medium Green	Amount
Semipaste white lead	100 lb.
Chrome oxide green paste in oil	20 lb.
Raw linseed oil	3¼ gal.
Varnish	½ gal.
Turpentine or mineral volatile spirits	1 qt.
Yield (approximate)	8¼ gal.

Sec. 2C–3.3—Hot-Applied Coal-Tar Enamel

Such coating material shall meet the requirements of the applicable provisions of A.W.W.A. Standard Specifications for Coal-Tar Enamel Protective Coatings for Steel Water Pipe (7A.5–

1940 and 7A.6–1940). Application must conform exactly to the instructions of the manufacturer of the product used.

Sec. 2C–3.4—Wax-Grease Paint

Wax-grease coatings may be either of the cold-application type or of the type adapted for hot application.

Section 2C–4—Application of Paint

Sec. 2C–4.1—Red Lead and Oil or Red Lead and Synthetic Resin

Red-lead paint may be applied either by spraying or by brushing. If applied by spraying, care shall be taken that suitable nozzles are used and that the air pressure, both on the liquid in the container and on the atomizing nozzle, is within the ranges recommended by the paint and equipment manufacturers to produce good work. If the spray method is used, care shall be taken that no spray falls on near-by structures. Spraying of exterior surfaces shall be confined to quiet days when it will not adversely affect adjacent property. The contractor shall be responsible for any and all damage resulting from spray drifting.

If the paint is applied by brushing, it shall be brushed on in one direction and then smoothed in a direction at right angles, to produce as uniform a thickness of coat and as complete a coverage as possible. (This required two-directional brushing is "one coat" within the meaning of this procedure.)

Care shall be taken to insure the application of a uniform coating carefully worked around rivet heads, joints and other irregularities in the surface.

Each coat shall be allowed to dry thoroughly before the next coat is applied; however, not more than 48 hours shall elapse between successive interior coats of the phenolic type vehicle.

Paint shall be applied only when the air temperature is at or above 40°F. No paint shall be applied during wet or foggy weather, or upon damp surfaces or metals coated by frost.

Sec. 2C–4.2—Coal-Tar Enamels

The detailed recommendations of the manufacturer shall govern the application of coal-tar enamels.

The coal-tar primer shall be evenly applied and care exercised to avoid runs, festoons or other accumulations of heavy primer. No coal-tar primer shall be applied when the steel temperature is below 35°F.

After the coal-tar primer is dry, the surfaces will receive the application of the hot coal-tar enamel. If more than five days have elapsed since the coal-tar primer was applied, the surfaces shall be given a light thinned coat of coal-tar primer and this application allowed to dry.

The coal-tar enamel shall be broken up into small pieces and heated in a suitable melting kettle. A slow flame shall be used for the initial heating before the flame is turned on full force.

When the hot enamel is drawn from the heating kettle, it shall be strained through a fine wire screen to remove all foreign substances.

Immediately before applying the hot coal-tar enamel, the primed surfaces shall be wiped free of any dust or foreign matter.

Sec. 2C–4.3—Wax-Grease Paints—Cold-Application Type

Cold-application type wax-grease paints shall be thoroughly rubbed on to

the clean dry metal with a stubby brush to insure thorough wetting of the metal surface and absorption of all occluded moisture. The coating shall be applied to a thickness of not more than 0.0312 in. and not less than 0.0234 in.

The tank can, if needed, then be put into service as soon as the painting is complete.

Sec. 2C–4.4—Wax-Grease Paints—Hot-Application Type

Because of its physical properties and special method of application, it is recommended that the hot-application type of wax-grease paint be applied only by an experienced painting contractor, who is properly equipped to handle this material.

The material shall be applied to the dry surfaces by means of a spray apparatus, utilizing fluid pressure through special nozzles. Sufficient pressure shall be used to impinge the molten material on the metal surface. The temperature of the coating shall be not less than 250°F. and not more than 300°F. After application to the surface, the coating should be thoroughly flashed or flamed by means of a torch, to smooth out all laps and close any pinholes. The thickness of applied coating shall be not less than 0.0315 in. or more than 0.0625 in.

Section 2C–5—Ventilation

The contractor must provide adequate ventilation while painting the interior surfaces of a tank. This is particularly important where tar products are used. The ventilation shall be adequate to remove fumes and prevent injury to workmen or the possibility of accumulating volatile gases.

Section 2C–6—Cleanliness

The contractor and all workmen employed by him shall conduct all operations in a clean and sanitary manner. No nuisance shall be committed in a tank; the workmen shall either use proper waste receptacles or leave the tank whenever necessity arises.

No one shall work in a tank if he has been under a physician's care, or has needed a physician's care, within a seven-day period prior to entering or working in the tank. No person shall be permitted to work in a tank who has an abnormal temperature or gives evidence of illness. The tank owner, or a physician employed by him, shall be the judge of the physical fitness or unfitness of any person to enter or work in a tank. No deviation from this stipulation may be permitted.

The tank owner, after work of any nature is done in a tank, is charged with satisfying himself that the tank interior is clean and sanitary before the tank is returned to service. Although a contractor may be required by his contract to clean all painted surfaces thoroughly before a tank is restored to service, it is the ultimate responsibility of the tank owner either to give the tank a final field inspection or to require such laboratory tests of the quality of water held (for test purposes) in the tank as will demonstrate the good sanitary condition of the tank interior. (See the note on disinfection procedure at the end of this document.)

Section 20–7—Inspection

The owner shall inspect the painting as it is being done or employ an inspector to do so. Payment for painting done shall be made only after the owner has satisfied himself directly that the painting is satisfactory; or after an inspector's report has been filed with the owner certifying that the painting has been done properly and in accordance with the terms of the contract.

It is in the mutual interest of the owner and the contractor that such inspection be made promptly.

NOTE

Disinfection Procedure. After inspection, repair or painting has been completed, a tank should be disinfected before it is replaced in service. This should be done following the leakage test and general inspection of the work. If the tank is not used for water service between the repair and painting operations, intermediate disinfection is not necessary.

The tank should be slowly filled to the overflow level with potable water, to which enough chlorine is added to provide a concentration of 50 ppm. Cl in the full tank.

The chlorine, either as high-test calcium hypochlorite (H.T.H., Perchloron or equivalent) or liquid chlorine, should be introduced into the water as early during the refilling operation as possible. A simple and effective method of adding the disinfectant consists of scattering hypochlorite powder over the water surface in the partly filled tank—working from the manhole or entry opening on or near the top of the tank. As the water rises to fill the tank, the chlorine will be dissolved and dispersed so that it will make contact with the metal surfaces. After the tank has been filled, it should stand full for 24 hours, if possible, but for not less than 6 hours. (Disinfection with chlorine at the 50-ppm. rate is practically instantaneous, *if* the polluting material is not protected by films or gross particles. The 6-to-24-hour holding requirement is intended to provide a factor of safety.)

After the holding period, the highly chlorinated water in the tank must be completely drained to waste and the tank refilled from the regular supply. Subsequent to refilling, samples of water should be taken from the tank in order to demonstrate and record the good sanitary condition of the tank, before it is restored to regular service.

The tank owner and the inspector, the repair contractor or the painting contractor shall, prior to any work in the tank, reach a definite understanding concerning the disinfection procedure to be used, and shall assign responsibility for the actual task of disinfection, recording this understanding in the contract.

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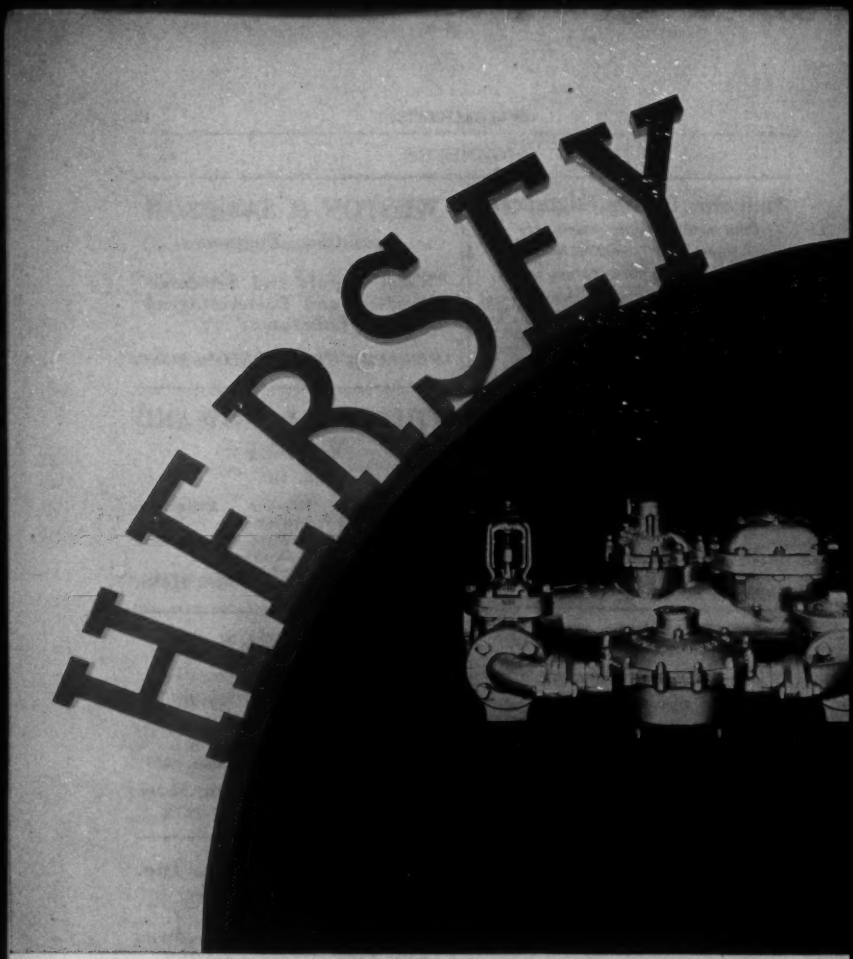

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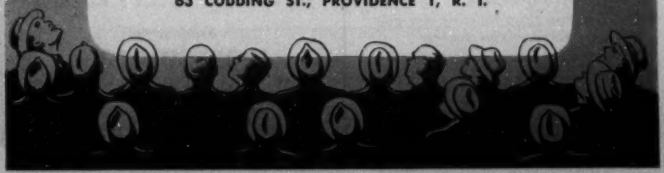

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"Watch Dog" models . . . made in standard capacities from 20 gpm up: frost-proof and split case in household sizes. Disc type, Turbine type or Compound type. Write for Bulletin.

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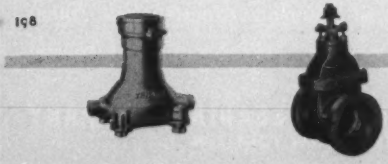
This union will benefit the industry by making available to each of the two Companies added engineering and technical experience in manufacturing, and a more complete coverage in the field for Sales and Service.



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How Many Service Calls Will You Have THIS Winter to Thaw Frozen Water Pipes?

From November 1 to February 1 last winter in Boston (to choose a local example) there were only four days during which temperatures did not skid below freezing. As a result, water companies had many service calls to clear frozen pipes—one in Maine reported 275 calls! Frozen pipes have a serious effect:

INTERRUPTED SERVICE. Interrupted service means a dissatisfied public, loss of revenue, and criticism of city administration.

FIRE HAZARD. Frozen house pipes or fire hydrants are serious hazards during the period when fire incidence is greatest.

POOR SANITATION. Lack of water for sewage disposal, food preparation, and cleansing can result in spreading of disease and lowering of health standards.

Thawing pipes *electrically* with Westinghouse FlexArc is the best answer for several reasons:

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PAYS FOR SELF. One winter's savings will amortize it.

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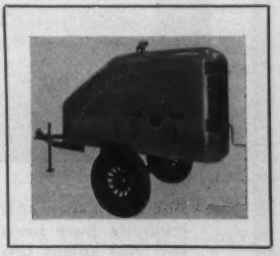
AVAILABLE NOW. FlexArcs are in New England warehouses ready for immediate delivery.



300 amp 2-wheel mounted FlexArc DC gas-engine welder. Also 200 or 400 amps, 4-wheel or skid mounting, 1, 2 or 3 KW auxiliary generator.

Write for new leaflet "Thawing Pipes with the New FlexArc."

Westinghouse Electric Corporation, Room 406, 10 High Street, Boston, Massachusetts.

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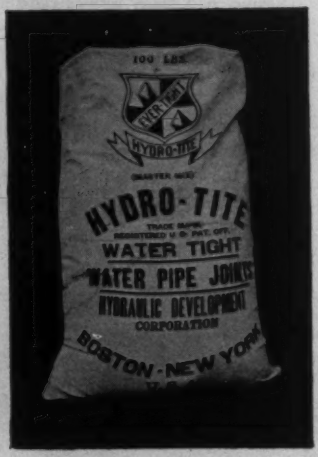

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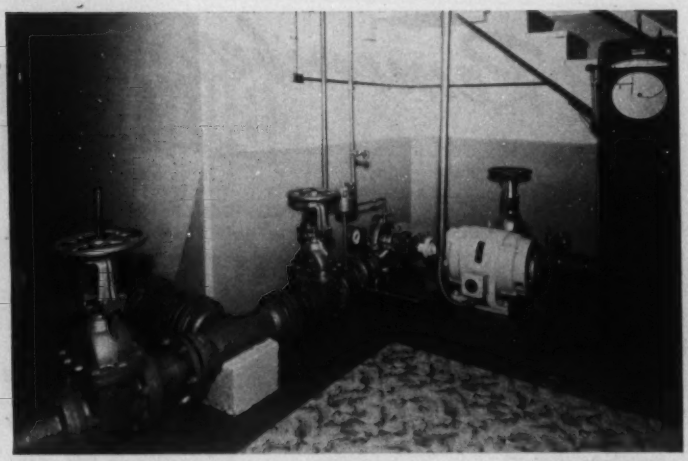

One of the two Fairbanks-Morse motor driven Centrifugal pumping units in HUDSON, Mass., Municipal Pumping Station.

Town officials at Hudson, Mass., are pleased with the "Undivided Responsibility" they have obtained through the team-work of their Fairbanks-Morse Pumps, driven by Fairbanks-Morse Motors.

When additional gallonage became necessary to supply the increased population and care for industrial expansion, the Town of Hudson drove a well field and installed two Fairbanks-Morse Centrifugal Pumps, driven by Fairbanks-Morse Motors. Installed by the R. P. Hall Company of Boston, these Pumps are now giving Hudson low-cost Pumping efficiency.

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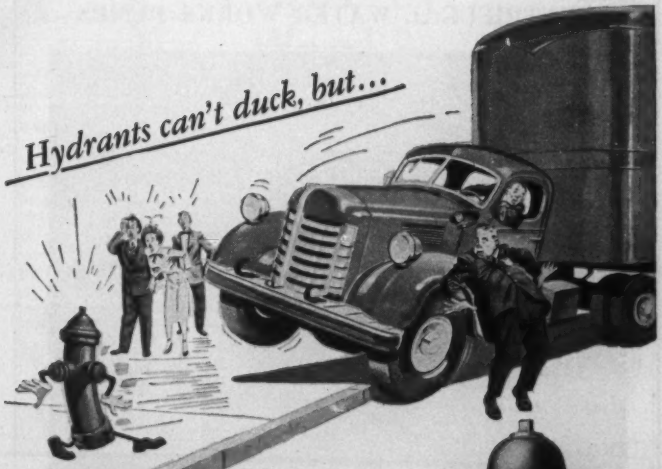

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A fire hydrant hasn't been made that can dodge an accident. But when a Kennedy Safetop Hydrant is struck a smashing blow which no hydrant can withstand, only the Safety Breakable Section gives way. The essential working parts of the hydrant are left undamaged, the danger of injury to persons or property is minimized and the cost of repair is far less.

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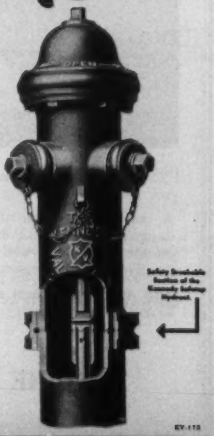

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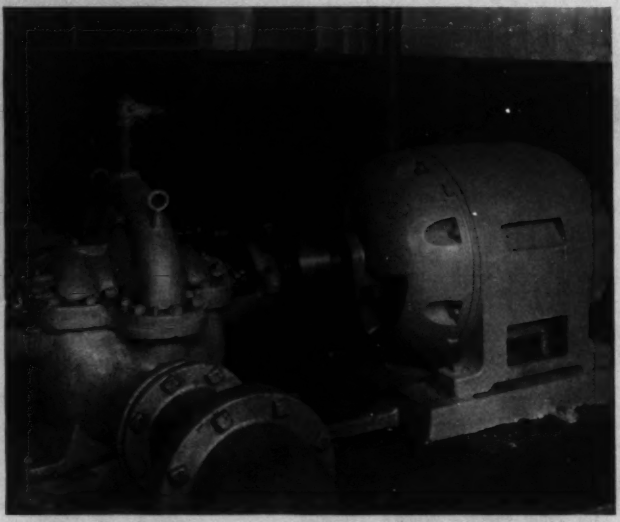

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This new unit replaces an old De Laval pump that was retired after more than 25 years of satisfactory service because of increased water demand.

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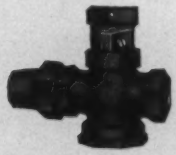

CATALOG No. 5040
Hays Curb Stop for copper inlet to female iron pipe outlet.

CATALOG No. 5016
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HAYS corporation and curb stops are easy to install and are interchangeable with the products of any other manufacturers. They are good for many long years of trouble-free service. They are made of the best 85-5-5-5 bronze and plugs are precision ground for perfect fit. They are hydrostatically tested at 200 pounds or more and specially lubricated for permanent easy turning. HAYS corporation stops can be installed with any standard tapping machine equipment.

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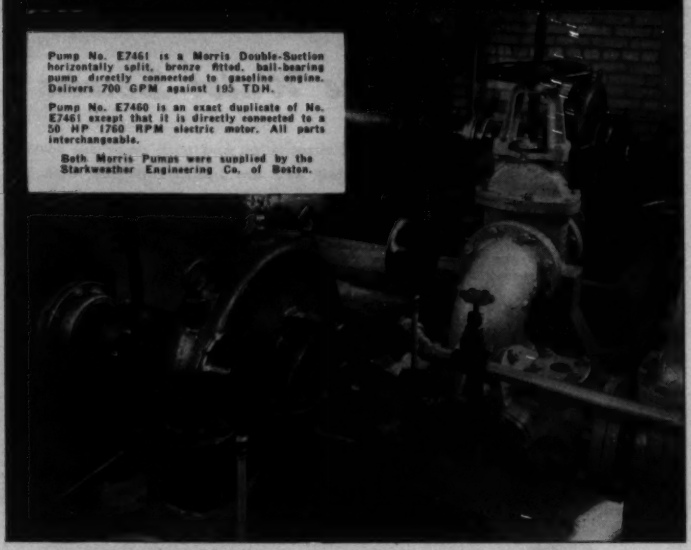

Pump No. E7461 is a Morris Double-Suction horizontally split, bronze fitted, ball-bearing pump directly connected to gasoline engine. Delivers 700 GPM against 195 TDH.

Pump No. E7460 is an exact duplicate of No. E7461 except that it is directly connected to a 50 HP 1760 RPM electric motor. All parts interchangeable.

Both Morris Pumps were supplied by the Starkweather Engineering Co. of Boston.

IN the past few years, the Town of Westborough, Mass. has been growing so rapidly that it needed another pumping station to supply water to outlying districts.

The well-known firm of Metcalf & Eddy, Boston Engineers, designed the new water system. Morris Pumps were installed in the High Service pumping station and are now operating as booster units.

The two Morris Pumps illustrated, draw water through approximately 80 feet of suction piping and discharge through 6,150 feet of force main.

The Morris pumps have been in satisfactory operation since 1947. And, if the past performance records of Morris Pumps are any indication, Westborough's Morris Pumps will continue to operate satisfactorily for many years to come.

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Reduction of organic growths was not the only benefit however. According to the report "•••Aside from destroying the organic growth in the transmission line, 'break-point' chlorination has proved of value to us in other ways. Since beginning this treatment, taste and odor flare ups have been practically nonexistent. We are assured a sterile water throughout the entire plant and lactose-fermenting organisms in the plant are a thing of the past.•••"

This experience at Little Rock is representative of the multiple protection that you can obtain with the Break-Point Process. For complete details on other Break-Point benefits such as longer filter runs and iron and manganese removal, see your nearest W&T Representative.

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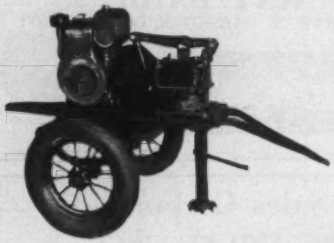

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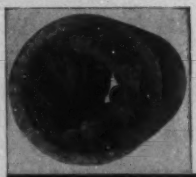

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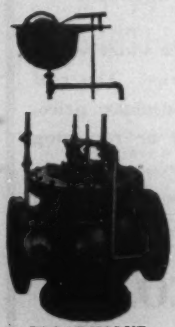

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Fig. 238

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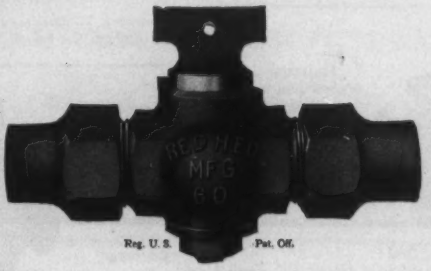

Fig. 415

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- **time needed to lay the line**

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